SOA Research INSTITUTE

Mortality and Longevity

Aging and Retirement

U.S. Population Mortality Observations

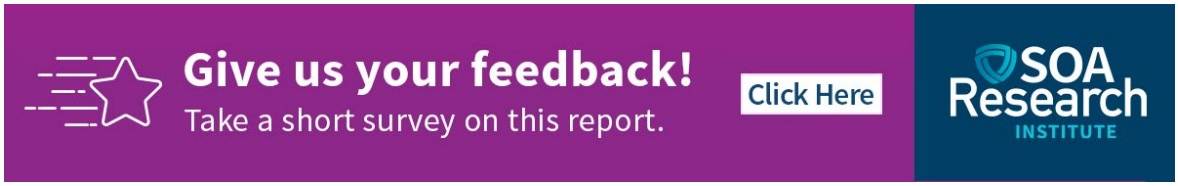
Updated with 2022 Experience

MARCH | 2025

U.S. Population Mortality Observations

Updated with 2022 Experience

AUTHOR R. Jerome Holman, FSA, MAAA



CONTENTS

U.S. Population Mortality Observations

Updated with 2022 Experience

Section 1: Introduction

The Society of Actuaries Research Institute has developed this report to provide insights on the historical levels and emerging trends in U.S. population mortality. This report combines publicly released deaths by cause of death and publicly released population estimates to produce otherwise non-public estimates of one-year mortality rates and associated mortality improvement rates for years ending 2020-2022. This data has been incorporated and added to prior available data to enable analysis of U.S. population mortality experience over the period 1999-2022. Due to the lack of easily available data by county for the population adjustments, there is no analysis by socio-economic regions in this report. This research is part of the Institute's ongoing longevity and mortality research initiatives. The report begins with an Executive Summary, which contains key highlights, followed by analyses of mortality by a number of factors, including sex, age group, and cause of death (COD). The report is supplemented with a companion online interactive dashboard that allows users to pursue mortality analysis by key attributes.

Section 2: Executive Summary

This report updates prior annual reports on U.S. population mortality with 2022 experience. It takes a novel approach to enable comparisons to pre-COVID mortality by using 2019 as the baseline year instead of a conventional comparison to prior year 2021 mortality. The key measure in the report is a direct comparison of 2022 to 2019 mortality on a non-annualized cumulative basis. The report also analyzes mortality change by year for 2020, 2021, and 2022.

2.1 KEY TAKEAWAYS

Relative to pre-pandemic experience:

- Pandemic-related negative mortality improvement, for all causes of death combined, moderated in 2022 with and without COVID.
- Cancer was the only COD to have continued positive mortality improvement in each year during the pandemic.
- Circulatory diseases, kidney, liver, and diabetes were very negatively impacted. All had negative cumulative 2019-2022 mortality improvement which was also less than their average annual 2009-2019 improvement.
- Opioids 2022 one-year mortality improvement, which was slightly negative, continued a strong increase from the pandemic low of very negative one-year improvement seen in 2020.

2.2 DETAILED HIGHLIGHTS

- Alternative mortality rates for 2019-2022 than those provided in WONDER[1], which is the normal source of all data for this report, were estimated and used because of concerns about the accuracy of population estimates in WONDER for recent years. The alternative mortality rates have been incorporated and added to prior available data to enable analysis of U.S. population mortality experience over the period 1999-2022. Generally, the effect of using the alternative data relative to prior reporting is to increase one-year 2021 improvement rates. Cumulative mortality improvement for 2019-2021 was -18.6% which was higher than the -23.0% corresponding improvement stated in last year's report. The associated 2021 one-year improvement was -1.5% which was also higher than the previously reported -5.3%. All analysis in the report for 2019-2022 is based on these alternative estimated mortality rates as described in Section 7.

- Independent of whether COVID was included or removed, 2020-2022 had sharply lower mortality improvement that stands in stark contrast with pre-COVID mortality experience. But the large mortality increase of the first year of the pandemic has moderated and reversed to a mortality decrease both with and without COVID in the most recent year. The overall age-adjusted[2] cumulative mortality improvement rate from 2019-2022 (both sexes) from all causes of death, was -10.1%. When COVID deaths were removed, the baseline 2019-2022 cumulative mortality improvement rate was -4.0%. The corresponding one-year mortality improvement rates with and without COVID were 7.1% and 0.5%, respectively, for the year ending 2022.

- Six natural causes of death, diabetes, heart, hypertension, kidney, liver, and stroke had higher mortality rates in 2022 than 2019. Each of those CODs also had cumulative 2019-2022 mortality improvement that was less than its 10-year 2009-2019 annual average. And each COD, except for kidney, had declining or flattening mortality rates in 2022. Diabetes, hypertension, and liver had 2019-2022 cumulative improvement of -10.2%, -13.4% and

[1] https://wonder.cdc.gov/wonder/help/main.html#What%20is%20WONDER

[2] Age-adjusted rates are calculated assuming the mix of ages in the population stays the same each year. Life expectancy is a composite of mortality rates over a single person's future lifetime. This report focuses on age-adjusted rates (2000 baseline year), as opposed to life expectancy, because actuaries generally require mortality rates, not life expectancies, as an input assumption for their work.

-22.2%, respectively. Notably, these CODs had cumulative 2019-2022 improvement that was at least 10% or more lower than their prior 10-year average annual improvement. Heart, kidney, and stroke had 2019-2022 cumulative improvement of -1.8%, -6.6% and -5.0%, respectively. Heart and stroke had one-year 2022 improvement rates that were in line with their 10-year average annual improvement rates before the pandemic. But kidney saw quite different experience where mortality rates increased each year during the pandemic. Its one-year 2022 improvement of -4.1% was notably lower than its prior 10-year average annual improvement of 1.7%.

- Cancer was the only leading cause of death covered in this report to have lower mortality rates in each successive year since 2019. The 2019-2022 cumulative mortality improvement for all forms of cancer was 3.8%. The year ending 2022 posted a one-year improvement rate of 1.6% which was only slightly lower than the 10-year annual average improvement of 1.7% from 2009-2019.

- Key cancer types had mortality experience that were like, and in some instances contrasted with, the experience of all forms of cancer combined. Notably each of these cancer types, breast, colon, lung, and prostate cancer all had positive 2019-2022 cumulative mortality improvement. Breast and lung cancer had improvement patterns like all forms of cancer combined but with higher rates. Cumulative 2019-2022 improvement that had decreased mortality rates in each successive year of the period was 4.3% for breast cancer and a notably high 11.4% for lung cancer. Like all forms of cancer combined colon cancer had its lowest one-year improvement in the second year of the pandemic and while it was negative, its 2019-2022 cumulative improvement rate was 2.0%. Prostate cancer also had 2019-2022 cumulative improvement of 2.0% but the pattern within that period was different than these other forms of cancer. During the 2019-2022, its highest one-year improvement of 2.1% occurred the year ending 2021 which was followed by a decrease to 0.7% in the year ending 2022.

- Three natural CODs other than cancer—Alzheimer's/dementia, flu & pneumonia, and pulmonary—also had lower 2022 mortality rates than in 2019. But their pattern of improvement generally saw the highest one-year improvement rates in the year ending 2021 that fell substantially in 2022. The 2019-2022 cumulative improvement for Alzheimer's/dementia, flu & pneumonia, and pulmonary was, respectively, 5.1%, 10.0% and 11.8%, but one-year improvement ending 2022 was, respectively, 0.6%, -10.2% and -0.9%. Although near term mortality improvement decreased in 2022, the mortality rates for flu & pneumonia and pulmonary were below their 2009 levels and in line with the trend since then. Alzheimer's/dementia remained well above 2009 levels but with nearly flat improvement of 0.6% in 2022, mortality rates returned to a level in line with 2019 pre-pandemic experience.

- The external CODs of accidents excluding opioids, suicide, and assault, each had negative cumulative mortality improvement from 2019-2022. But 2022 had higher one-year improvement rates than 2021 for each of these CODs. The cumulative 2019-2022 mortality improvement of -14.4% for accidents excluding opioids was a substantial deterioration from pre-pandemic experience but moderated to a one-year 2022 improvement of 2.7%. Assaults had 2019-2022 cumulative improvement of -29.9% which tied accidents (inclusive of accidental opioid deaths) for the lowest improvement of all leading causes of death. But like accidents excluding opioids, assaults improvement reversed and had one-year improvement of 4.2% in 2022. Suicides had comparatively less severe -2.9% cumulative improvement in 2019-2022. And although improvement increased in 2022, its one-year improvement was -1.3%.

- Opioids saw a substantial moderation of mortality rate increases during 2019-2022. While the cumulative 2019-2022 improvement rate was -63.4%, the associated one-year improvement rates followed a steep monotonically increasing pattern that started at -38.5% in 2020 and was -1.2% in 2022. Although the opioid death rate is much lower compared to other major CODs, it had a large impact on young adults where opioid deaths were 26% of all causes of death for age group 25-34 in 2022. Fentanyl and tramadol opioid death rates were much higher than those from heroin, methadone, and natural and semi-synthetic opioids. The 2019-2022

cumulative mortality improvement for fentanyl and tramadol was -97.5%. But like opioids as a whole, the associated one-year improvement rates for these opioids followed a substantially increasing short term trend of -55.1% and -3.1% in the years ending 2020 and 2022.

- Cumulative mortality improvement in 2019-2022 varied substantially by age group, both with and without COVID, and by sex. Generally, mortality improvement was higher by age. With COVID included, every age group and sex combination saw increased mortality over this period. With COVID excluded, there were limited instances of flat or slightly lower mortality at ages 75-84 and 85+. Mortality increases for juvenile ages from 1-4 and 5-14 from 2019-2022 were at least 10% for both sexes with and without COVID. Generally, in 2019-2022 a low of improvement by age occurred in a trough at ages 25-34 and 35-44 for every combination with and without COVID and for both sexes. With COVID included, the lowest 2019-2022 improvement for females and males occurred at ages 35-44 that saw rates of -25.0% and -32.9%, respectively. Without COVID the same ages saw the lows of -19.8% and -28.9% for females and males, respectively. Ages 45 and older saw increasing improvement rates by age that were all negative with COVID. But without COVID, where those improvement rates were about 5%-7% higher than with COVID, female ages 75-84 peaked at 0.0% and male ages 75-84 and 85+ saw the highest improvement where each age group had 1.4% improvement.
- Female and male mortality patterns for all ages combined were similar but reflected greater impact of adverse mortality for 2019-2022 cumulative mortality improvement on males than females, both with and without COVID. With COVID, female and male mortality improvement was -9.2% and -10.6%, respectively, and was -3.4% and -4.1%, respectively, without COVID. Both sexes had higher one-year improvement rates in 2022 than 2021 with COVID, but when COVID was excluded, male improvement increased but female improvement decreased in 2022 relative to 2021.
- The assignment of the underlying cause of death by certifiers involves judgement within recommended guidelines that were updated in 2020 for COVID and published earlier for general application by the CDC in 2003. Readers of this report should be aware that similar circumstances may be viewed differently by individuals, and practices may have evolved over time such that consistency of the assignment of the underlying COD could be affected. This is particularly important for this report covering the first year of the COVID pandemic. More information on this with references cited are in Section 9 of this report.

Section 3: Total Population and by Sex

The overall age-adjusted[3] mortality improvement rate for all causes of death and both sexes in 2022 relative to 2019 (not annualized), where pre-COVID 2019 mortality just before the pandemic serves as a baseline in this report, was -10.1%. To distinguish between this measure and references to one-year mortality improvement ending in 2020, 2021, and 2022 that are also cited in the report, it is referred to throughout the report as a three-year cumulative mortality improvement measure. This three-year period included one-year 2019-2020 mortality improvement of -16.9% that was the historically lowest mortality improvement of published records[4] dating back to 1900. Mortality improvement increased in the second year of the pandemic with a one-year -1.5% mortality improvement rate during 2020-2021 and increased further during 2021-2022 to 7.1%.

When COVID deaths are removed, the baseline three-year 2019-2022 cumulative mortality improvement rate was -4.0%, which stands in stark contrast to the average annual mortality improvement rates pre-COVID of 1.5% and 0.5% for the ten-year periods ending 2009 and 2019, respectively. Mortality improvement also increased in the second year of the pandemic with COVID removed, but to a smaller extent than inclusive of COVID. The one-year mortality improvement rates were -4.9%, 0.4%, and 0.5% for the years ending 2020, 2021, and 2022, respectively. The all causes excluding COVID 2022-2023 one-year improvement was 2.1%. The rolling 12-month improvement rate ended Q1 2024 was 0.5%.Error! Bookmark not defined.

When viewed by sex, cumulative 2019-2022 mortality improvement for all causes of death was lower for males at -10.6% than females at -9.2%. The same rank order of mortality improvement by sex applied in each of the two years of the pandemic but reversed in 2021-2022. One-year mortality improvement rates for males and females were -17.9% and -15.5% in 2020, respectively, -2.1% and -0.7% in 2021, respectively, and 8.0% and 6.1% in 2022, respectively. When COVID deaths are removed, the pattern by sex is the same as for all CODs. The cumulative 2019-2022 mortality improvement rates for males and females of -4.1% and -3.4%, respectively, were comprised of one-year mortality improvement rates that for males and females were -5.1% and -4.4% in 2020, respectively, -0.1% and 1.0% in 2021, respectively, and 1.1% and -0.1% in 2022, respectively.

[3] Age-adjusted rates are calculated assuming the mix of ages in the population stays the same each year. Life expectancy is a composite of mortality rates over a single person's future lifetime. This report focuses on age-adjusted rates (2000 baseline year), as opposed to life expectancy, because actuaries generally require mortality rates, not life expectancies, as an input assumption for their work.

[4] Age-Adjusted Death Rates for Selected Causes, Death Registration States, 1900-32, and United States, 1933-98 https://www.cdc.gov/nchs/nvss/mortality/hist293.htm

Table 1

U.S. POPULATION MORTALITY IMPROVEMENT BY SELECTED PERIODS

All Ages	Average Annual Improvement		Cumulative Improvement	Average Annual Improvement			Cumulative Improvement	Average Annual Improvement		
			With COVID				Without COVID			
	1999-2009	2009-2019	2019-2022	2019-2020	2020-2021	2021-2022	2019-2022	2019-2020	2020-2021	2021-2022
All	1.5%	0.5%	-10.1%	-16.9%	-1.5%	7.1%	-4.0%	-4.9%	0.4%	0.5%
Male	1.8%	0.5%	-10.6%	-17.9%	-2.1%	8.0%	-4.1%	-5.1%	-0.1%	1.1%
Female	1.4%	0.5%	-9.2%	-15.5%	-0.7%	6.1%	-3.4%	-4.4%	1.0%	-0.1%

Section 4: Age Group

Table 2 shows cumulative mortality improvement in 2019-2022 varied substantially by age group, both with and without COVID, and by sex regarding excess COVID mortality. With COVID included, every age group and sex combination saw increased mortality over this period. Age less than one had the highest mortality improvement during this period for both sexes with female and male rates of -2.1% and -0.1%, respectively. Mortality improvement rates for all other age groups were substantially lower in a range of -25.0% to -5.9% for females and -32.9% to -5.8% for males. For the age groups 1-4 and higher, both sexes had their lowest improvement rates for age group 35-44 and had their highest rates for age group 75-84.

When COVID was excluded for the cumulative measure of 2019-2022 mortality improvement, the same general pattern of mortality improvement differences across age groups as seen with COVID included prevailed. But the highest improvement rates were flat or positive for a small set of age groups. Female age group 75-84 had flat improvement while male age groups <1, 75-84, and 85+ saw small positive improvement. Across all age groups the range of the low to high improvement for females was -19.8% to 0.0% and for males was -28.9% to 1.4%. Like experience with COVID, the lowest mortality improvement occurred at age group 35-44 for females and males. Coincidentally that same low for females also occurred at age group 25-34.

The mortality improvement due to COVID is determined as the difference of the mortality improvement, both with and without COVID, and is shown in the table below as the COVID excess. The impact of COVID to increase mortality resulted in a generally decreasing pattern of COVID excess across age groups that moderated with a slight increase for females at the highest ages and minimum values occurring at the highest age groups for males. Age group 55-64 had the lowest female COVID excess of -7.0% while the male low of -7.3% occurred for age group 85+. The difference in the COVID excess between males and females was greatest at the younger working ages and lowest at the older ages. Because of the weight of higher mortality rates at the highest ages where males had a lower COVID excess than females, the COVID excess for all ages combined was lower for males, -6.6%, than females at -5.8%.

Table 2

U.S. POPULATION 2019-2022 CUMULATIVE MORTALITY IMPROVEMENT BY AGE AND SEX

	Female			Male			Male-Female COVID Excess
Age Group	With COVID	Excl COVID	COVID Excess	With COVID	Excl COVID	COVID Excess	
< 1	-2.1%	-1.4%	-0.7%	-0.1%	0.6%	-0.7%	0.0%
1-4	-17.0%	-14.3%	-2.7%	-22.4%	-19.2%	-3.1%	-0.5%
5-14	-17.1%	-14.4%	-2.7%	-15.0%	-12.8%	-2.2%	0.5%
15-24	-18.7%	-16.5%	-2.2%	-16.8%	-15.6%	-1.2%	1.0%
25-34	-23.4%	-19.8%	-3.6%	-28.0%	-25.6%	-2.4%	1.1%
35-44	-25.0%	-19.8%	-5.3%	-32.9%	-28.9%	-4.1%	1.2%
45-54	-14.1%	-7.5%	-6.6%	-19.5%	-13.5%	-6.0%	0.6%
55-64	-13.1%	-6.1%	-7.0%	-13.5%	-7.1%	-6.3%	0.6%
65-74	-11.2%	-4.3%	-6.9%	-11.4%	-4.3%	-7.1%	-0.2%
75-84	-5.9%	0.0%	-5.9%	-5.8%	1.4%	-7.2%	-1.3%
85+	-6.4%	-1.2%	-5.2%	-5.9%	1.4%	-7.3%	-2.1%
All Ages	**-9.2%**	**-3.4%**	**-5.8%**	**-10.6%**	**-4.1%**	**-6.6%**	**-0.8%**

4.1 MORTALITY ATTRIBUTION BY AGE GROUP

The attribution by age of 2019-2022 cumulative mortality improvement varied across age and by inclusion or exclusion of COVID. Whether COVID was included or excluded, ages under 15 had no contribution to the attribution of mortality improvement. When COVID was included, the attribution for age groups 15-24 to 85+ generally decreased by age group to a low of -1.9% for ages 85+. Those same ages saw a concave pattern with the effects of COVID excluded that were -0.2% for ages 15-24, -0.1 for ages 85+ and reached a low of -1.1% for ages 35-44. Because all age groups with COVID had negative mortality improvement and only age group 75-84 without COVID had positive mortality improvement, a more negative attribution amount reflects a greater contribution to the total -10.1% and -4.0% mortality improvement with and without COVID, respectively.

The attribution of mortality improvement for an age group is, in part, determined by its proportion of the mortality for all ages. The older age groups' attribution of mortality change will naturally be magnified relative to other ages. When COVID is included, working age groups 25-34 through 55-64 produced a combined attribution to improvement of -4.5% or 45% of total -10.1% improvement while age groups 65-74 through 85+ produced -5.3% or 52% of the total. Although improvement rates were lower for the working ages than senior ages the higher mortality rates of seniors caused their relative contribution to the attribution of improvement to have greater net impact than the working ages. The combined impact of the older ages, working and senior, was 97% of the mortality improvement for all ages. When COVID is excluded the combined impact for the same sets of ages is similar but with more weight shifted to the 25-64 working ages. Ages 25-34 through 55-64 contributed -3.2% or 80% to total -4.0% improvement and ages 65-75 through 85+ contributed -0.6% or 15% of the total improvement. Their combined impact across all age groups was 95% of total -4.0% mortality improvement.

Table 3

U.S. POPULATION ATTRIBUTION OF 2019-2022 CUMULATIVE MORTALITY IMPROVEMENT BY AGE

Age Group	Deaths per 100,000		Mortality Improvement		Attribution of Mortality Improvement*	
	2022	2022 w/o COVID	2019 to 2022	2019 to 2022 w/o COVID	2019 to 2022	2019 to 2022 w/o COVID
< 1	559.5	555.7	-1.0%	-0.3%	0.0%	0.0%
1-4	27.7	27.1	-20.0%	-17.1%	0.0%	0.0%
5-14	15.1	14.7	-15.9%	-13.4%	0.0%	0.0%
15-24	81.0	80.0	-17.4%	-15.9%	-0.2%	-0.2%
25-34	163.3	159.7	-26.6%	-23.8%	-0.6%	-0.6%
35-44	254.3	245.6	-30.2%	-25.7%	-1.3%	-1.1%
45-54	452.3	428.4	-17.4%	-11.2%	-1.2%	-0.8%
55-64	986.9	929.6	-13.3%	-6.7%	-1.4%	-0.7%
65-74	1,966.4	1,842.7	-11.3%	-4.3%	-1.8%	-0.7%
75-84	4,737.7	4,443.7	-5.9%	0.7%	-1.6%	0.2%
85+	15,403.7	14,527.8	-6.4%	-0.3%	-1.9%	-0.1%
All Ages	**814.5**	**769.1**	**-10.1%**	**-4.0%**	**-10.1%**	**-4.0%**

* The attribution method is described in Section 7.

Section 5: Cause of Death

This section covers mortality by the 14 individual causes of death (CODs), including COVID, that were selected from the National Center for Health Statistics' (NCHS) list of rankable causes of death. The remainder of Section 5 provides more detailed analysis for 11 CODs: COVID, heart, cancer, Alzheimer's/dementia, diabetes, liver, hypertension, kidney, accidents excluding opioids, opioids, and suicide.

5.1 CAUSE OF DEATH DISTRIBUTION BY AGE GROUP

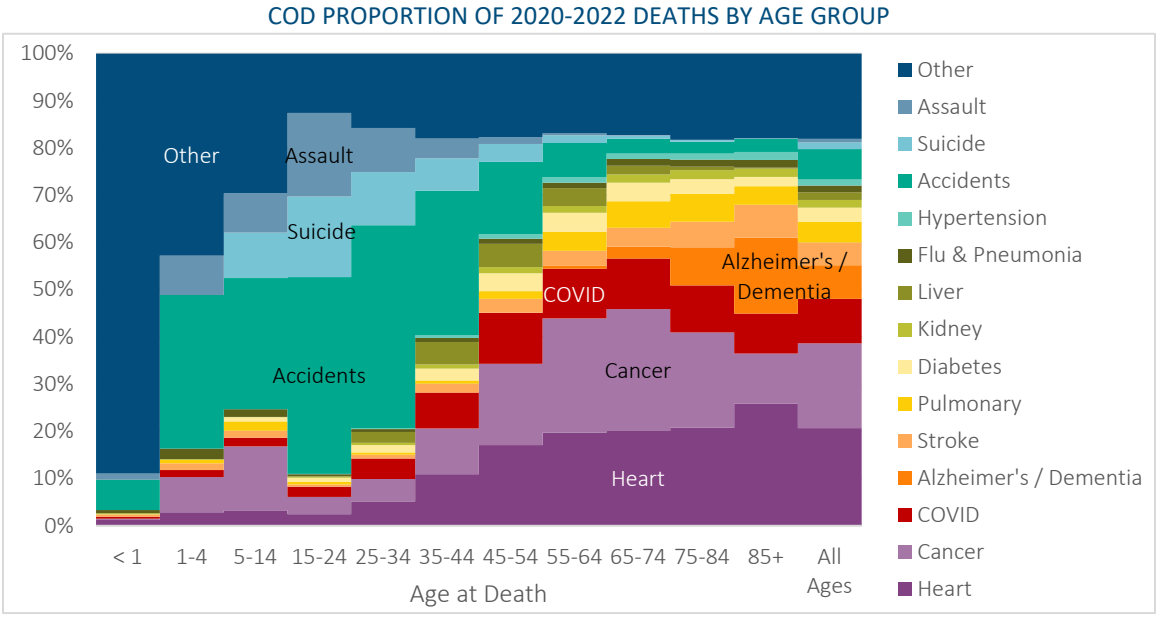
Considering the 14 individual causes of death highlighted here, physiological CODs predominated for older working and senior ages. The proportions of total deaths (including Other CODs) ranged from 61.8% for age group 45-54 to a high of 79.2% at ages 85+. The proportion of all deaths (including Other CODs) as external CODs (assault, suicide, and accidents) was higher than the proportion of physiological deaths for all age groups 35-44 and under. The highest proportion of external CODs, 76.4%, occurred for ages 15-24. Other CODs are not classified here as to physiological or external cause. Their proportion of deaths, 89.0%, was the highest for age < 1. From age group 35-44 to 85+, the proportion of Other deaths ranged in a tight band of 16.9% to 18.3% across all of those age groups.

While physiological deaths are a lower proportion for younger ages, heart, cancer, COVID, and Alzheimer's/dementia combined are a majority of deaths within physiological causes for age groups 55-64 and higher. The combined percentage of deaths from those four CODs ranged from 55.0% for age group 55-64 to 61.0% for age group 85+. Within the mix of those four CODs and those age groups, heart and Alzheimer's/dementia had an increasing share of deaths by age. While heart deaths were in a tight range of 19.7% to 20.8% for age groups 55-64 to 75-84 and then increased to 25.9% at ages 85+, the increase was much more pronounced for Alzheimer's/dementia across those same age groups. Deaths from Alzheimer's/dementia increased in an exponential like pattern from age group 55-64 at 0.6% to 16.1% at ages 85+. COVID shares were relatively flat across the same age groups, except at ages 85+. Shares for age groups from ages 55-84 ranged from 10.0% to 10.7% and peaked for age group 65-74, while ages 85+ had a smaller 8.4% share. Cancer peaked at age group 65-74 with 25.8% of deaths and declined to 10.6% for age group 85+.

The combination of the other physiological CODs shown, stroke, pulmonary, diabetes, kidney, liver, flu & pneumonia, and hypertension, produced at least 10% of the deaths for age groups 35-44 and higher. The combined percentage of deaths of those seven CODs for those age groups ranged from a low of 12.1% for age group 35-44 to 19.9% for age group 75-84. Within the mix of those seven CODs for those age groups, stroke, pulmonary, kidney, hypertension, and flu & pneumonia generally increased with advancing age, liver decreased with that same age progression, while diabetes had a hump-shaped share progression that had a flat mesa like peak at age groups 55-64 and 65-74.

External deaths were more than 40% of total deaths for each age group from 1-4 to 35-44. For these age groups, accidents ranged from 27.8% for ages 5-14 to nearly identical portions of 41.7% and 42.9% for age groups 15-24 and 25-34, respectively. The highest proportion of deaths across all age groups from assault, 17.7%, and suicide, 17.0%, occurred for ages 15-24. Those deaths were a contributing factor to the largest share of external deaths, 76.4%, that occurred in this age group. It is notable that assault deaths of 8.4% were reported for age group 1-4. External deaths and accidents within that grouping are much lower for older ages. The proportion of external deaths at age group 45-54 was 20.5% and decreased to 2.9% for each of age groups 75-84 and 85+. Accidents, which comprised the largest portion of external deaths, followed a similar decreasing pattern where age groups 45-54 and 85+ accident deaths were 15.3% and 2.7%, respectively, of all deaths for those age groups.

Figure 1



5.2 MORTALITY ATTRIBUTION BY CAUSE OF DEATH

U.S. population deaths decreased to 3,279,857 in 2022 from 3,464,231 in 2021 which in that year were the highest in history. Although one-year decreases in deaths have occurred numerous times previously, this is the first occurrence since 2009.[5] Heart disease remained the number one killer, and accidents continued to be the highest external[6] COD in 2022. The number of deaths in 2020-2022 for the population by the CODs studied in this report are shown below in descending rank order. The attribution of COVID to the total eclipsed all other CODs and contributed -6.1% to the -10.1% cumulative 2019-2022 mortality improvement rate.

Cancer, pulmonary, Alzheimer's/dementia, and flu & pneumonia had improved mortality in 2019-2022. Cancer had one-year improvement each year during the period while pulmonary and Alzheimer's/dementia a mix of negative and positive mortality improvement. The most recent trend for those two CODs was a sharp decrease. Based on all ages and both sexes, Alzheimer's/dementia mortality improvement decreased from 11.7% in 2021 to 0.6% in 2022 and pulmonary decreased from 8.4% to -0.9% during the same two years, respectively. Flu & pneumonia reflected the very low incidence of it during the COVID pandemic in 2020-2021 but also saw a sharp falloff of improvement in the following year. Flu & pneumonia one-year mortality improvement decreased from 22.7% to -10.2% in the years ending 2021 and 2022, respectively. Taken together, the four CODs with positive 2019-2022 cumulative improvement produced a 2.0% offset to all other CODs' -12.1% negative mortality improvement.

Except for COVID and the Other COD classification, accidents were the largest contributor to attributed mortality improvement. It's very low -29.9% three-year cumulative mortality improvement rate produced a -2.0% contribution to total mortality improvement. While assault is a small proportion of all deaths, it continues to be very prevalent for young adults. It was a top five cause of death for males under age 35 and females under age 25, and it was the number two cause of death for males ages 15-24. Assault mortality improvement for all ages combined was -29.9% in 2019-2022,

[5] Based on individual years 1933 and later data through 2022 obtained through HMD (Human Mortality Database). Max Planck Institute for Demographic Research (Germany), University of California, Berkeley (USA), and French Institute for Demographic Studies (France). Available at, www.mortality.org, on 11/18/2024.

[6] See Section 7 for definition of external COD.

which contributed -0.2% to total mortality improvement. Heart disease was the next largest impact to mortality improvement after COVID and accidents. Its -1.8% mortality improvement translated into a -0.4% contribution to total mortality improvement. Diabetes, kidney, hypertension, liver, and stroke all had negative mortality improvement at or lower than -5.0%. The range of diabetes, kidney, and liver mortality improvement rates, -22.2% to -6.6%, produced a combined -0.7% to total mortality improvement. Hypertension and stroke improvement rates of -13.4% and -5.0%, respectively, produced a combined -0.5% to total mortality improvement.

Table 4

U.S. POPULATION ATTRIBUTION OF 2019-2022 CUMULATIVE MORTALITY IMPROVEMENT BY COD

Cause of Death	2020-2022 Deaths	%	Age-Adjusted 2019-2022 Mortality Improvement	Attribution to All CODs*
Heart Disease	2,095,389	20.7%	-1.8%	-0.4%
Cancer	1,815,934	17.9%	3.8%	0.8%
COVID	954,276	9.4%	n/a	-6.1%
Alzheimer's/Dementia	724,205	7.2%	5.1%	0.4%
Accidents	652,929	6.4%	-29.9%	-2.0%
Stroke	488,547	4.8%	-5.0%	-0.3%
Pulmonary	442,381	4.4%	11.8%	0.6%
Diabetes	306,691	3.0%	-10.2%	-0.3%
Kidney	164,842	1.6%	-6.6%	-0.1%
Liver	163,030	1.6%	-22.2%	-0.3%
Suicide	143,638	1.4%	-2.9%	-0.1%
Flu & pneumonia	142,513	1.4%	10.0%	0.2%
Hypertension	128,016	1.3%	-13.4%	-0.2%
Assault	75,456	0.7%	-29.9%	-0.2%
Other	1,829,970	18.1%	-10.9%	-2.1%
ALL COD	**10,127,817**	**100.0%**	**-10.1%**	**-10.1%**

* The attribution method is described in Section 7.

5.3 MORTALITY ATTRIBUTION BY CAUSE OF DEATH BY AGE GROUP

The impact of specific causes of death on age group mortality improvement varied across ages and across the cumulative 2019-2022 period in comparison to one-year improvement in 2021-2022. When COVID is included in this type of analysis, it was the main driver of sharply lower cumulative 2019-2022 mortality improvement for most age groups and for the moderation to subsequently higher one-year improvement in 2021-2022 than the first two years ending 2020 and 2021. Because COVID overshadowed all other CODs it is excluded in this analysis shown in Tables 5 and 6 to highlight the impact of all other CODs.

Table 5 shows that the greatest contributors to negative cumulative mortality improvement in 2019-2022 were accidents up to age group 55-64 and Other which notably impacted ages 1-4, 5-14, and ages 65-74 and older. Cancer and pulmonary provided generally the highest offsetting positive improvements for ages 45-54 and older.

Table 5

U.S. POPULATION ATTRIBUTION OF 2019-2022 CUMULATIVE MORTALITY IMPROVEMENT BY COD AND AGE

Cause of Death	< 1	1-4	5-14	15-24	25-34	35-44	45-54	55-64	65-74	75-84	85+
Heart	0.1%	0.6%	-0.8%	0.1%	-0.5%	-1.6%	-1.3%	-1.7%	-1.3%	0.1%	0.4%
Cancer	0.1%	0.1%	-1.4%	-0.1%	-0.2%	-0.1%	0.8%	1.3%	1.0%	1.3%	0.2%
Alzheimer's/Dementia	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-0.1%	-0.2%	0.4%	1.2%
Stroke	0.1%	0.0%	-0.3%	0.0%	0.0%	-0.4%	-0.3%	-0.4%	-0.4%	-0.1%	-0.3%
Pulmonary	0.0%	-0.1%	0.8%	-0.1%	0.0%	-0.1%	0.3%	0.3%	0.6%	1.0%	0.7%
Diabetes	0.0%	0.0%	-0.4%	-0.2%	-0.5%	-0.7%	-0.8%	-0.6%	-0.3%	-0.2%	-0.2%
Kidney	0.1%	0.0%	0.0%	0.0%	-0.1%	-0.3%	-0.3%	-0.2%	-0.2%	0.0%	-0.1%
Liver	0.0%	0.0%	0.0%	-0.1%	-1.2%	-2.3%	-1.0%	-0.6%	-0.3%	-0.1%	0.0%
Flu & pneumonia	0.0%	-0.4%	-0.2%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.2%	0.4%
Hypertension	0.0%	0.0%	0.0%	0.0%	-0.1%	-0.2%	-0.2%	-0.2%	-0.2%	-0.1%	-0.2%
Accidents	-0.6%	-5.9%	-3.5%	-9.4%	-14.8%	-14.1%	-5.5%	-2.6%	-0.8%	-0.2%	-0.2%
Suicide	0.0%	0.0%	0.6%	-0.1%	-1.1%	-0.5%	0.0%	0.1%	0.0%	0.0%	0.0%
Assault	0.0%	-2.2%	-3.8%	-4.8%	-2.4%	-1.4%	-0.5%	-0.1%	0.0%	0.0%	0.0%
Other	0.0%	-9.2%	-4.3%	-1.1%	-2.8%	-4.0%	-2.5%	-1.9%	-2.1%	-1.7%	-2.2%
All COD Exlc COVID	**-0.3%**	**-17.1%**	**-13.4%**	**-15.9%**	**-23.8%**	**-25.7%**	**-11.2%**	**-6.7%**	**-4.3%**	**0.7%**	**-0.3%**

Individual CODs attribution percentages may not add to All COD due to rounding.

Table 6 shows that the largest contributors by COD to attribution of All COD one-year improvement in 2021-2022 amplified some and mitigated other 2019-2022 COD cumulative mortality improvement patterns. Juvenile ages 1-4 and 5-14 saw continued notable mortality increases due to Other causes. This brought the 2019-2022 cumulative improvement of those ages closer to older ages than was the case a year earlier. Every age group saw higher 2021-2022 one-year accident improvement than the corresponding three-year cumulative values. Those differences were hump shaped being flat at the youngest and oldest ages and peaked at ages 25-34 having one-year improvement of 1.8% and lower three-year improvement of -14.8%. And whereas heart had negative three-year cumulative improvement from ages 25-34 to 65-74 it had positive one-year improvement in 2021-2022. But the opposite occurred at ages 85+ where one-year 2021-2022 improvement was negative.

Table 6

U.S. POPULATION ATTRIBUTION OF 2021-2022 ONE-YEAR MORTALITY IMPROVEMENT BY COD AND AGE

Cause of Death	< 1 year	1-4 years	5-14 years	15-24 years	25-34 years	35-44 years	45-54 years	55-64 years	65-74 years	75-84 years	85+ years
Heart	0.2%	0.3%	-0.4%	0.3%	0.5%	0.6%	1.2%	0.7%	0.2%	0.5%	-0.5%
Cancer	0.1%	0.3%	-0.8%	-0.2%	0.0%	0.1%	0.0%	0.4%	0.4%	0.7%	0.1%
Alzheimer's/Dementia	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-0.1%	0.0%	0.2%	0.0%
Stroke	0.1%	0.1%	-0.2%	0.1%	0.0%	0.1%	0.1%	0.1%	0.0%	0.2%	-0.1%
Pulmonary	0.0%	-0.2%	-0.1%	-0.1%	0.0%	0.0%	0.1%	0.1%	-0.1%	0.0%	-0.2%
Diabetes	0.0%	0.0%	0.0%	0.1%	0.1%	0.1%	0.1%	0.2%	0.2%	0.2%	0.0%
Kidney	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	-0.1%	-0.1%	-0.1%	0.0%	-0.1%
Liver	0.0%	0.0%	0.0%	0.0%	0.1%	0.4%	0.6%	0.2%	0.0%	0.0%	0.0%
Flu & pneumonia	-0.1%	-2.2%	-1.4%	-0.1%	-0.1%	-0.1%	-0.1%	-0.1%	-0.1%	-0.1%	-0.2%
Hypertension	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%
Accidents	-0.1%	-0.4%	1.3%	3.4%	1.8%	-0.1%	-0.1%	-0.2%	-0.2%	0.0%	0.0%
Suicide	0.0%	0.0%	1.7%	1.5%	0.3%	-0.2%	-0.2%	-0.2%	0.0%	0.0%	0.0%
Assault	0.1%	-1.1%	-1.1%	1.2%	1.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%
Other	-0.4%	-6.7%	-4.6%	0.6%	0.7%	1.3%	1.0%	0.5%	0.0%	-0.1%	-0.9%
All COD Excl COVID	**-0.1%**	**-9.9%**	**-5.6%**	**6.5%**	**4.5%**	**2.1%**	**2.7%**	**1.7%**	**0.3%**	**1.4%**	**-2.1%**

Individual CODs attribution percentages may not add to All COD due to rounding.

5.4 COVID

The overall age-adjusted one-year mortality improvement rate for 2021-2022 (both sexes) from COVID increased to 56.4% from -17.7% in the prior year. The difference between sexes (all ages) was relatively small where females and males had improvement rates of 55.4% and 56.4%, respectively, in 2021-2022. Mortality was less than one per 100,000 for ages under 15 years in each year 2020-2022. Age groups 15-24 and higher had widely varying and generally decreasing mortality improvement where, in 2021-2022, improvement ranged from a low of 34.6% for age group 85+ to a high of 76.3% for age group 35-44. All age groups from 15-24 to 55-64 had improvement above 60% and age groups 65-74 and 75-84 had improvement exceeding 50%. This was in sharp contrast to the prior year where mortality improvement for age groups 15-24 through 85+ had monotonically increasing improvement rates that were at their low of -179.0% for age group 15-24 and maximum of 25.9% for age group 85+. Age groups 75-84 and 85+ were the only two sets of ages that had positive improvement in both years ending 2021 and 2022.

Mortality improvement by sex for all ages combined was 55.4% and 56.4% for females and males, respectively, for 2021-2022. Given the large degree of improvement for age groups 15-24 and above, the maximum absolute difference of mortality improvement of 4.8% between females and males by age group was relatively small. The relatively small difference of mortality improvement across these age groups in 2021-2022 contrasted strongly to the same differences in 2020-2021. The difference of COVID mortality improvement appears to have converged in 2022 when in 2021 there were large differences across several age groups. In 2021 the maximum absolute mortality improvement difference was 56.6% for age group 35-44 where females and males had improvement of -198.0% and -141.4%, respectively.

Table 7

2020-2022 COVID MORTALITY IMPROVEMENT BY AGE AND SEX

Age Group	Annual Mortality Improvement					
	2020 - 2021			2021 - 2022		
	All	Female	Male	All	Female	Male
< 1	-169.5%		-98.2%	-50.7%	-24.0%	-79.2%
1-4				-90.7%	-60.7%	-118.5%
5-14	-191.7%	-197.1%	-187.6%	6.9%	-0.9%	13.0%
15-24	-179.0%	-192.0%	-170.8%	68.4%	68.4%	68.3%
25-34	-173.0%	-187.7%	-165.2%	73.3%	71.9%	74.0%
35-44	-160.2%	-198.0%	-141.4%	76.3%	73.9%	77.7%
45-54	-119.6%	-143.5%	-107.9%	73.7%	70.6%	75.4%
55-64	-76.2%	-92.7%	-67.0%	66.7%	64.8%	68.0%
65-74	-30.4%	-41.5%	-23.6%	59.5%	59.4%	59.5%
75-84	0.6%	1.1%	0.2%	51.8%	51.7%	51.9%
85+	25.9%	30.9%	19.3%	34.6%	36.1%	33.1%
All Ages	**-17.7%**	**-16.8%**	**-18.0%**	**56.4%**	**55.4%**	**56.4%**

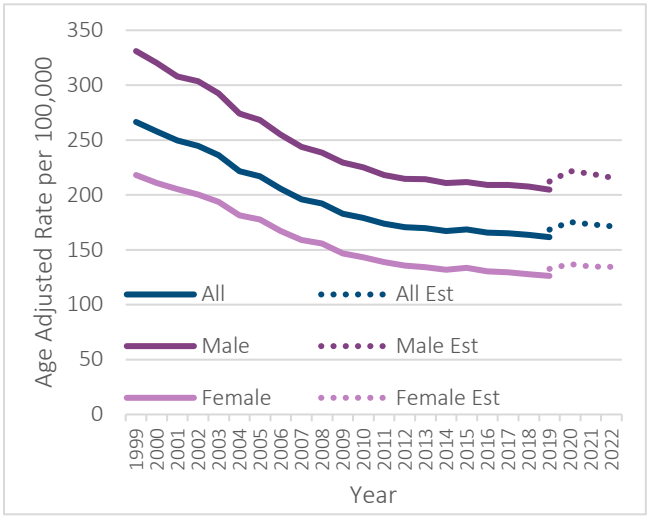
5.5 HEART DISEASE

The cumulative mortality improvement rate over 2019-2022 for heart disease was -1.8%. During 2019-2022 the lowest one-year improvement rate which occurred in the year ending 2020 was -4.1%. Mortality improvement in the years ending 2021 and 2022 was 1.3% and 1.0%, respectively. Because heart deaths are highly concentrated in senior ages above age 64, those age groups had the greatest influence in producing the results for all ages combined. Males had lower mortality improvement of -1.7% in 2019-2022 than females at -1.4%. One-year mortality improvement was higher for females in the years ending 2020 and 2021 and higher for males in the year ending 2022. Male and female mortality improvement rates for 2021-2022 were 1.6% and 0.2%, respectively.

There is no apparent pattern across all age groups of cumulative 2019-2022 mortality improvement rates. But age groups 55-64 to 85+ had increased cumulative mortality improvement by age group during that period. Cumulative mortality improvement rates from 2019-2022 for age groups 55-64 and 85+ were -7.9% and 1.3%, respectively. The same pattern of increased mortality improvement by age for this same range of ages occurred in the one-year periods ending 2020 and 2021. Although age group 75-84 had a higher mortality improvement rate of 2.0%, compared to 0.9% for age group 65-74 in the year ending 2022, the general pattern that year was decreased mortality improvement by age for the broader range of age groups 55-64 to 85+. During year ending 2022 age groups 55-64 and 85+ saw mortality improvement rates of 3.0% and -1.8%, respectively. It is notable that while the proportion of age group 5-14 heart deaths is relatively small, this age group had the lowest 2019-2022 cumulative mortality improvement rate of -25.0%. It was the only age group that had positive mortality improvement in 2019-2020 followed by negative one-year mortality improvement in each of the years ending 2021 and 2022. During 2019-2022 the age group 5-14 one-year mortality improvement rates were 5.6%, -19.3%, and -11.1%, respectively, for the years ending 2020-2022.

Figure 2

2022 HEART HISTORICAL MORTALITY RATES AND MORTALITY IMPROVEMENT BY SELECTED PERIODS



All Ages	Average Annual Improvement		Cumulative Improvement*	Average Annual Improvement *		
	1999-2009	2009-2019	2019-2022	2019-2020	2020-2021	2021-2022
All	3.7%	1.2%	-1.8%	-4.1%	1.3%	1.0%
Male	3.6%	1.1%	-1.7%	-4.5%	1.1%	1.6%
Female	3.9%	1.5%	-1.4%	-3.3%	1.6%	0.2%
Age Group (includes both sexes)						
< 1	3.5%	3.0%	7.6%	7.9%	-13.5%	11.6%
1 - 4	2.3%	1.2%	17.8%	14.1%	-5.7%	9.5%
5 - 14	2.4%	2.0%	-25.0%	5.6%	-19.3%	-11.1%
15 - 24	1.5%	1.5%	3.6%	0.0%	-8.2%	10.9%
25 - 34	-0.2%	0.2%	-9.2%	-14.4%	-4.7%	8.8%
35 - 44	1.2%	0.6%	-13.0%	-14.8%	-3.5%	4.9%
45 - 54	1.5%	0.8%	-6.5%	-11.2%	-2.1%	6.1%
55 - 64	3.4%	0.0%	-7.9%	-9.5%	-1.5%	3.0%
65 - 74	4.9%	0.8%	-6.1%	-6.3%	-0.7%	0.9%
75 - 84	4.1%	2.0%	0.6%	-2.8%	1.3%	2.0%
85+	3.3%	1.3%	1.3%	-1.0%	3.9%	-1.8%

* Estimated rates for 2019-2022 are derived using CDC WONDER death counts and modified population counts. 2019-2022 cumulative and average annual mortality improvement is derived with these rates. See Section 7 for details.

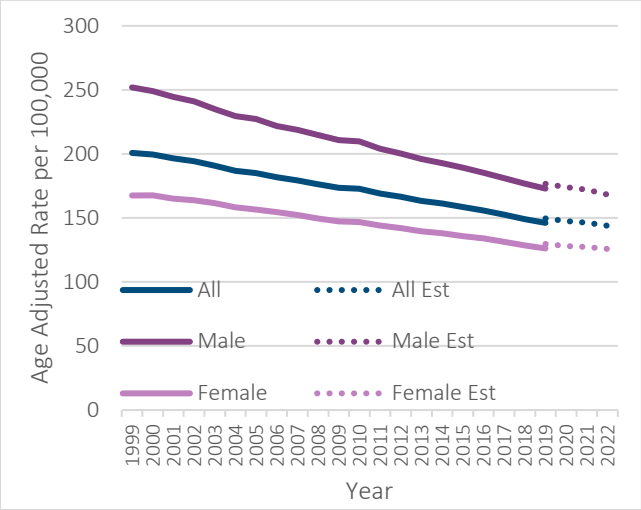
5.6 CANCER

The cumulative mortality improvement rate over 2019-2022 for cancer was 3.8%. Males had higher mortality improvement of 4.8% in 2019-2022 than females at 3.0%. That was a continuation of the long-term trend where male average annual mortality improvement rates were higher than the corresponding average annual female rates in both prior 10-year periods. The short-term trend showed that both males and females had lower one-year mortality improvement rates in 2021 compared to 2020 and higher corresponding mortality improvement rates in 2022 than 2021. Both males and females had positive mortality improvement in each of the three years from 2019-2022. Males had higher mortality improvement in 2022 of 2.2% in comparison to 1.5% in 2020 while females had lower mortality improvement of 1.2% in 2022 compared to 1.3% in 2020.

Age group cumulative mortality improvement during 2019-2022 varied by age with no discernable pattern. But there was notable bunching of age groups where some had positive while others had negative mortality improvement during this period. Age groups 45-54 and higher all had positive cumulative mortality improvement rates from 2019-2022 and, with the exception of age 85+ in 2021, had positive mortality improvement rates for each one-year period during that span of time. Conversely, age groups 5-14 through 35-44 each had negative cumulative mortality improvement rates during 2019-2022. Age group 5-14 had the lowest cumulative mortality improvement rate, -10.0%, during that time. And it is notable that age groups 5-14 and 25-34 both had negative one-year mortality improvement rates in each year ending 2020-2022.

Figure 3

2022 CANCER HISTORICAL MORTALITY RATES AND MORTALITY IMPROVEMENT BY SELECTED PERIODS



All Ages	Average Annual Improvement		Cumulative Improvement*	Average Annual Improvement *		
	1999-2009	2009-2019	2019-2022	2019-2020	2020-2021	2021-2022
All	1.4%	1.7%	3.8%	1.4%	0.9%	1.6%
Male	1.8%	2.0%	4.8%	1.5%	1.2%	2.2%
Female	1.3%	1.5%	3.0%	1.3%	0.6%	1.2%
Age Group (includes both sexes)						
< 1	-0.3%	2.4%	25.3%	-0.1%	0.2%	25.2%
1 - 4	2.3%	1.8%	1.0%	-9.9%	6.3%	3.8%
5 - 14	1.2%	1.5%	-10.0%	-2.8%	-1.1%	-5.8%
15 - 24	1.7%	1.4%	-1.5%	5.7%	-1.1%	-6.5%
25 - 34	1.0%	1.4%	-2.5%	-0.3%	-1.5%	-0.7%
35 - 44	2.0%	1.6%	-1.1%	0.7%	-3.1%	1.2%
45 - 54	1.2%	2.6%	3.7%	1.5%	2.0%	0.2%
55 - 64	2.1%	1.4%	4.3%	1.4%	1.4%	1.6%
65 - 74	2.1%	2.0%	3.3%	1.0%	1.1%	1.2%
75 - 84	0.9%	1.9%	5.7%	1.4%	1.2%	3.1%
85+	0.6%	0.8%	2.1%	1.8%	-0.3%	0.6%

* Estimated rates for 2019-2022 are derived using CDC WONDER death counts and modified population counts. 2019-2022 cumulative and average annual mortality improvement is derived with these rates. See Section 7 for details.

5.6.1 KEY CANCER COMPONENTS

Cancers of the breast, colon, lung, and prostate all had positive cumulative mortality improvement rates from 2019-2022. Lung cancer had the highest improvement rate in this period while prostate and colon cancer had the lowest corresponding rates. Cumulative 2019-2022 mortality improvement rates were 11.3% (both sexes) for lung cancer, 2.0% for colon cancer (both sexes), and 2.0% for male prostate cancer. In 2022, lung cancer was the number one cancer cause of death for both sexes and colon cancer was the third highest. Relative to a ranking within sex, prostate and breast cancer deaths ranked third highest for males and females, respectively. Like the pattern for all ages and all forms of cancer combined, each of lung, colon, and breast cancer had one-year mortality improvement rates that dipped in 2020-2021 and then rebounded in the following year. In the year ending 2021, females had the lowest one-year improvement rate of -1.7% during the 2019-2022 span of all the cancer key components below. Prostate cancer did not fit that pattern during 2019-2022 and had its highest one-year mortality improvement rate of 2.1% in the year ending 2021 which then decreased to 0.7% in the following year.

Table 8

2022 KEY CANCER COMPNENTS HISTORICAL MORTALITY IMPROVEMENT BY SELECTED PERIODS

All Ages	Average Annual Improvement		Cumulative Improvement	Average Annual Improvement		
	1999-2009	2009-2019	2019-2022	2019-2020	2020-2021	2021-2022
Breast Cancer						
Female	1.8%	1.4%	4.3%	1.5%	1.1%	1.8%
Colon Cancer						
All	2.6%	2.0%	2.0%	1.4%	-0.9%	1.5%
Male	2.8%	2.1%	2.3%	0.4%	0.1%	1.8%
Female	2.7%	2.0%	2.1%	2.4%	-1.7%	1.4%
Lung Cancer						
All	1.4%	3.6%	11.3%	4.7%	2.7%	4.4%
Male	2.2%	4.2%	13.3%	5.0%	3.4%	5.5%
Female	0.4%	3.1%	9.1%	4.4%	1.8%	3.2%
Prostate Cancer						
Male	3.4%	1.9%	2.0%	-0.9%	2.1%	0.7%

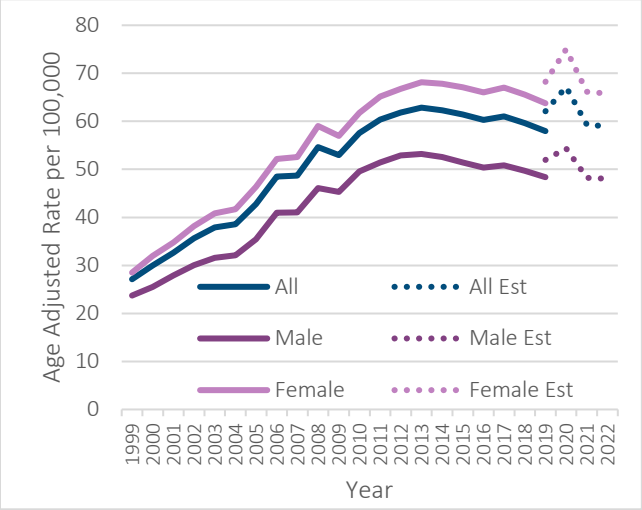
5.7 ALZHEIMER'S/DEMENTIA

The cumulative mortality improvement rate over 2019-2022 for Alzheimer's/dementia was 5.1%. But there were stark differences of improvement by year within this period. The three one-year periods ending 2020-2022 had improvement rates of -8.1%, 11.7%, and 0.6%, respectively. Males had higher 2019-2022 cumulative mortality improvement but that was due to a sharp difference in 2019-2020 where female and male one-year improvement was -9.9% and -4.7%, respectively. Female improvement was higher in each year ending 2021 and 2022 but by a much smaller difference. One-year female and male improvement in 2021 and 2022 was 0.6% and 0.4%, respectively. It is very notable that Alzheimer's/dementia is one of the few CODs where female age adjusted mortality rates are higher than the corresponding male rates and that the difference widened during the years covered in this report.

Age group cumulative mortality improvement during 2019-2022 varied widely by age. Deaths in age group 45-54 were less than one per 100,000. Ages 55 and higher saw increasing mortality improvement by age group that spanned a wide range for ages 55-64 at -15.2% to ages 85+ at 6.5%. Each of these same age groups had substantially lower one-year mortality improvement in 2022 than 2021. In that year, ages 55-64 and 65-74 had negative mortality improvement of -11.0% and -0.8%, respectively, while ages 75-84 and 85+ had small positive improvement of 2.0% and 0.2%, respectively.

Figure 4

2022 ALZHEIMER'S/DEMENTIA HISTORICAL MORTALITY RATES AND MORTALITY IMPROVEMENT BY SELECTED PERIODS



All Ages	Average Annual Improvement		Cumulative Improvement*	Average Annual Improvement *		
	1999-2009	2009-2019	2019-2022	2019-2020	2020-2021	2021-2022
All	-6.9%	-0.9%	5.1%	-8.1%	11.7%	0.6%
Male	-6.7%	-0.7%	7.5%	-4.7%	11.3%	0.4%
Female	-7.2%	-1.1%	3.6%	-9.9%	11.8%	0.6%
Age Group (includes both sexes)						
< 1						
1 - 4						
5 - 14						
15 - 24						
25 - 34						
35 - 44		5.2%				
45 - 54	-8.6%	1.2%	0.1%	7.9%	0.0%	-8.5%
55 - 64	-5.6%	-2.1%	-15.2%	-6.6%	2.6%	-11.0%
65 - 74	-5.1%	-1.3%	-6.4%	-13.4%	6.9%	-0.8%
75 - 84	-6.7%	-0.4%	4.6%	-8.4%	10.1%	2.0%
85+	-7.2%	-1.1%	6.5%	-7.6%	13.0%	0.2%

* Estimated rates for 2019-2022 are derived using CDC WONDER death counts and modified population counts. 2019-2022 cumulative and average annual mortality improvement is derived with these rates. See Section 7 for details.

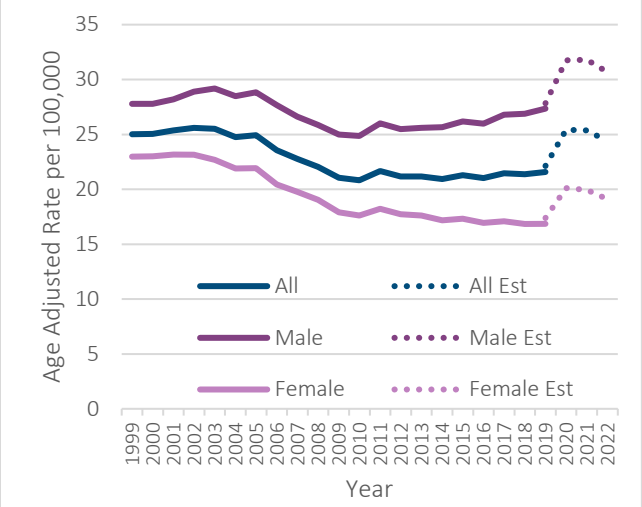
5.8 DIABETES

The cumulative mortality improvement rate over 2019-2021 for diabetes was -10.2%. Mortality improvement varied widely during the period. The cumulative improvement rate was driven largely by the very low one-year improvement rate of -14.9% in 2019-2020. Mortality improvement reversed in the following two years and posted one year improvement rates of 0.2% and 3.8% in the years ending 2021 and 2022, respectively. Female improvement for the cumulative period of 2019-2022 of -9.8% was higher than corresponding male improvement of -10.3%. Rank order by sex switched during the three-year period. Female improvement was lower than male improvement in 2019-2020 and then was higher than males in the following two years. Although female and male improvement increased to 4.3% and 3.5% for 2021-2022, the ending mortality rates were higher than the prior 2009-2019 trend line experience.

Each age group had negative 2019-2022 cumulative mortality improvement that varied widely. The most extreme negative mortality improvement in this three-year period occurred for the youngest ages that had the lowest death rates. Although variable within the trend, three-year cumulative mortality improvement generally increased with age. Focusing on ages 45 and higher, the three-year mortality improvement rate monotonically increased from -19.2% at ages 45-54 to -5.1% for ages 75-84 and bumped down slightly to -8.2% for ages 85+. Considering this same range of ages, each age group had higher and positive improvement in 2022 than 2021 except ages 85+. In that same range of ages, one-year mortality improvement in 2022 ranged from 2.7% for ages 45-54 to 5.5% for ages 75-84 and was -0.3% for ages 85+.

Figure 5

2022 DIABETES HISTORICAL MORTALITY RATES AND MORTALITY IMPROVEMENT BY SELECTED PERIODS



All Ages	Average Annual Improvement		Cumulative Improvement*	Average Annual Improvement *		
	1999-2009	2009-2019	2019-2022	2019-2020	2020-2021	2021-2022
All	1.7%	-0.3%	-10.2%	-14.9%	0.2%	3.8%
Male	1.1%	-0.9%	-10.3%	-14.1%	-0.1%	3.5%
Female	2.5%	0.6%	-9.8%	-15.7%	0.8%	4.3%
Age Group (includes both sexes)						
< 1						
1 - 4						
5 - 14	1.0%	1.1%	-88.5%	-116.6%	13.7%	-0.9%
15 - 24	0.4%	-4.2%	-29.6%	-26.1%	-10.3%	6.9%
25 - 34	-0.2%	-2.7%	-34.9%	-32.2%	-10.4%	7.6%
35 - 44	-0.5%	-1.7%	-25.1%	-29.0%	-0.7%	3.8%
45 - 54	0.1%	-2.0%	-19.2%	-20.4%	-1.7%	2.7%
55 - 64	1.7%	-1.3%	-14.2%	-16.1%	-4.0%	5.4%
65 - 74	2.7%	-0.5%	-8.1%	-13.9%	0.6%	4.6%
75 - 84	2.0%	0.5%	-5.1%	-11.5%	0.3%	5.5%
85+	1.1%	0.8%	-8.2%	-13.4%	4.9%	-0.3%

* Estimated rates for 2019-2022 are derived using CDC WONDER death counts and modified population counts. 2019-2022 cumulative and average annual mortality improvement is derived with these rates. See Section 7 for details.

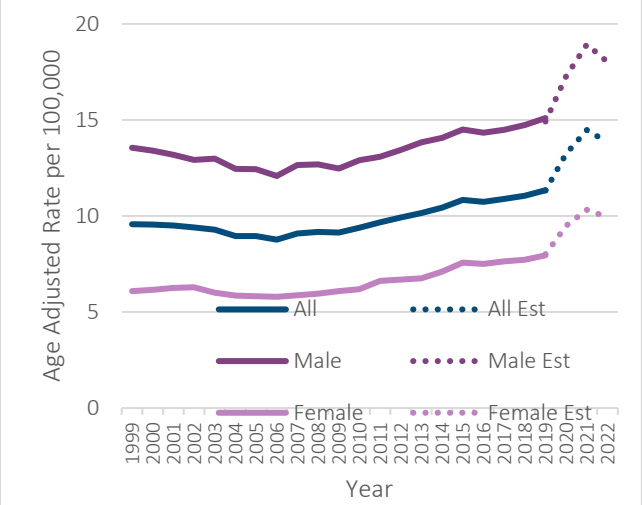
5.9 LIVER

The cumulative mortality improvement rate over 2019-2022 for liver was -22.2%. The cumulative improvement rate was driven largely by negative one-year improvement in the years ending 2020 and 2021 that posted rates of -16.9% and -9.3%, respectively. Mortality improvement in 2022 of 4.5% was a slight reversal from the prior two years. Female improvement for the cumulative period of 2019-2022 of -24.1% was lower than corresponding male improvement of -20.8%. Rank order by sex switched during the three-year period. Female improvement was higher than male improvement in the year ending 2021 but lower in the surrounding years ending 2020 and 2022. Although female and male improvement increased sharply to 3.7% and 4.8% for 2021-2022, the ending mortality rates were higher than the prior increasing 2009-2019 trend line experience.

Each age group had negative mortality improvement for the 2019-2022 cumulative period *and* each of the first two one-year periods ending 2020 and 2021. The most extreme negative cumulative mortality improvement in this two-year period occurred for the youngest ages that had much lower death rates. These mortality improvement rates generally increased with age with a low of -74.3% for age group 15-24 to a high of -10.4% for age group 75-84. Working ages all saw positive one-year improvement in 2022 while senior ages all had negative improvement that year. Working age mortality improvement in 2022 ranged from 2.5% for age group 15-24 to a peak of 10.1% at ages 45-54. Senior one-year mortality improvement in 2022 was higher for ages 65-84 but lower for ages 85+ than in 2021. Each of the senior age groups had negative improvement in each one-year period within 2019-2022. Notably, ages 85+ one-year mortality improvement reflected monotonically down trending experience in each year ending 2020 through 2022.

Figure 6

2022 LIVER HISTORICAL MORTALITY RATES AND MORTALITY IMPROVEMENT BY SELECTED PERIODS



All Ages	Average Annual Improvement		Cumulative Improvement*	Average Annual Improvement *		
	1999-2009	2009-2019	2019-2022	2019-2020	2020-2021	2021-2022
All	0.4%	-2.2%	-22.2%	-16.9%	-9.3%	4.5%
Male	0.8%	-1.9%	-20.8%	-15.8%	-9.6%	4.8%
Female	0.0%	-2.7%	-24.1%	-18.6%	-8.7%	3.7%
Age Group (includes both sexes)						
< 1						
1 - 4						
5 - 14						
15 - 24	2.4%	-3.9%	-74.3%	-42.8%	-25.2%	2.5%
25 - 34	-1.1%	-7.9%	-61.8%	-47.2%	-12.8%	2.6%
35 - 44	2.0%	-3.2%	-55.8%	-43.0%	-16.7%	6.7%
45 - 54	-0.7%	-0.6%	-19.2%	-18.9%	-11.6%	10.1%
55 - 64	-0.9%	-2.7%	-16.6%	-12.3%	-10.0%	5.6%
65 - 74	1.9%	-2.7%	-17.0%	-10.3%	-5.3%	-0.8%
75 - 84	1.6%	-1.7%	-10.4%	-7.3%	-1.5%	-1.4%
85+	0.9%	-2.3%	-11.4%	-2.1%	-3.5%	-5.4%

* Estimated rates for 2019-2022 are derived using CDC WONDER death counts and modified population counts. 2019-2022 cumulative and average annual mortality improvement is derived with these rates. See Section 7 for details.

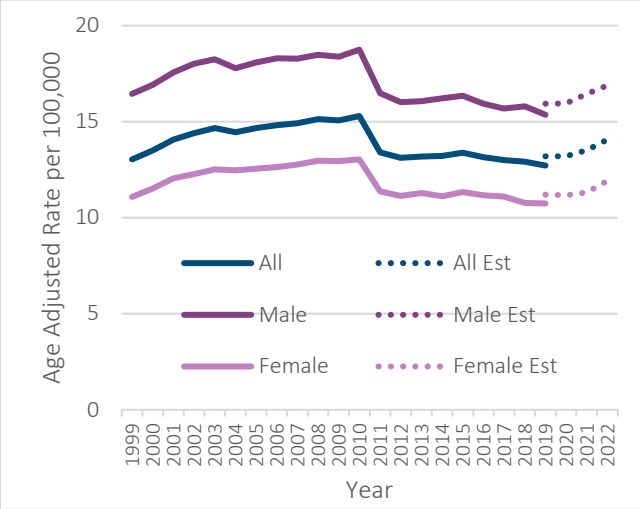
5.10 KIDNEY

The cumulative mortality improvement rate over 2019-2022 for kidney was -6.6%. The trend of one-year mortality improvement within 2019-2022 was very unusual. Whereas most CODs had large negative improvement in the first year of the pandemic, improvement for kidney was mostly flat. But it was followed by two years of negative improvement where one-year improvement for the year ending 2022 at -4.1% was lower than 2021 at -2.3%. Rank order of mortality improvement between the sexes switched in 2021 and 2022. Females had higher improvement in 2021 than males, -1.3% and -3.1%, respectively, and in 2021 female improvement was lower at -5.4% than males at -2.6%. The large disparity in 2022 between female and male improvement was the main driver of cumulative 2019-2022 female improvement, -6.5%, being lower than corresponding male improvement of -6.0%. And it is notable that mortality rate in 2022 was higher than the trend line of 2009-2019 experience and the associated post pandemic short term trend line went in the opposite direction toward higher mortality.

Each age group 25-34 and higher had negative mortality improvement for the 2019-2022 cumulative period. Working ages from 25-34 to 55-64 saw much lower improvement rates than senior ages. The lowest improvement of -30.9% of all ages occurred for ages 35-44. Senior ages had higher improvement rates than the working ages but were also all negative. The highest senior ages improvement rates were -2.0% and -3.0% for ages 75-84 and 85+, respectively. There was a general pattern of increased mortality improvement by age for one-year mortality improvement within 2019-2022, but it was less consistent than for the cumulative three-year period. Although the cumulative 2019-2022 working age mortality improvement rates were much lower than those for seniors the combination of the seniors' higher mortality and their population weight used to determine age adjusted rates resulted in their experience driving about 80% of the total result.

Figure 7

2022 KIDNEY HISTORICAL MORTALITY RATES AND MORTALITY IMPROVEMENT BY SELECTED PERIODS



All Ages	Average Annual Improvement		Cumulative Improvement*	Average Annual Improvement *		
	1999-2009	2009-2019	2019-2022	2019-2020	2020-2021	2021-2022
All	-1.5%	1.7%	-6.6%	0.0%	-2.3%	-4.1%
Male	-1.1%	1.8%	-6.0%	-0.1%	-3.1%	-2.6%
Female	-1.6%	1.9%	-6.5%	0.2%	-1.3%	-5.4%
Age Group (includes both sexes)						
< 1	4.5%	5.3%	36.0%	26.5%	-13.1%	23.0%
1 - 4						
5 - 14						
15 - 24	-0.6%	2.1%	6.7%	-0.3%	20.8%	-17.5%
25 - 34	-0.4%	0.0%	-19.4%	-6.7%	-15.3%	3.0%
35 - 44	-2.5%	0.9%	-30.9%	-11.7%	-11.8%	-4.8%
45 - 54	-2.6%	-0.6%	-21.3%	-4.6%	-8.4%	-6.9%
55 - 64	-1.2%	-0.2%	-15.8%	-6.1%	-3.2%	-5.8%
65 - 74	-0.4%	1.1%	-9.4%	-1.1%	-3.5%	-4.6%
75 - 84	-1.7%	2.2%	-2.0%	3.0%	-3.4%	-1.7%
85+	-1.8%	2.4%	-3.0%	0.8%	1.6%	-5.5%

* Estimated rates for 2019-2022 are derived using CDC WONDER death counts and modified population counts. 2019-2022 cumulative and average annual mortality improvement is derived with these rates. See Section 7 for details.

5.11 HYPERTENSION

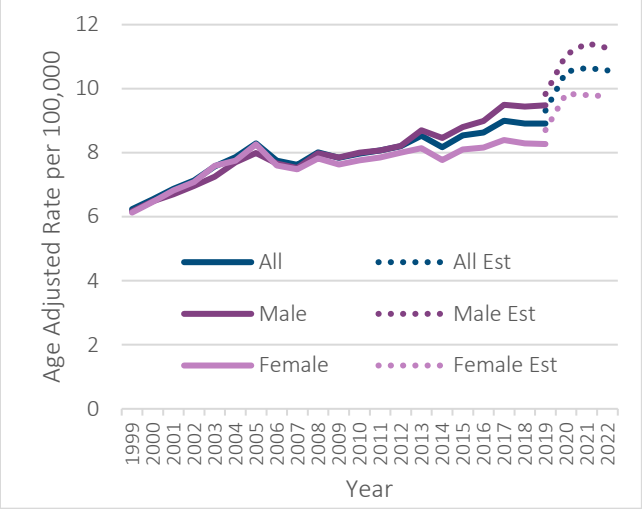
The cumulative mortality improvement rate over 2019-2022 for hypertension was -13.4%. This bulk of the cumulative improvement was incurred by very low one-year improvement in 2019-2020 of -13.0%. Cumulative 2019-2022 female and male mortality improvement was -12.1% and -14.6%, respectively. Rank order of improvement between sexes varied across the individual years within 2019-2022. Female improvement was lower in the years ending 2020 and 2022 while it was higher than males in 2021. The largest one-year improvement rate difference between females and males of 0.4% and -3.3% occurred in 2021 and was the biggest contributor to the difference across the 2019-2022 cumulative period. Mortality rates in 2022 were well above their 2019 pre-pandemic levels and above the trend of 2009-2019 experience that had a slight upward trend.

Each age group 25-34 and older had negative 2019-2021 cumulative mortality that varied widely and generally increased by age. Working ages from 25-34 to 55-64 saw much lower improvement rates than senior ages. The lowest improvement of -41.0% of all ages occurred for ages 25-34. Senior ages had higher improvement rates than the working ages but were also all negative. Ages 85+ had the highest improvement rate of all age groups of -9.3%. The years ending 2020 and 2021 also saw generally increasing improvement by age but with less consistency than for the 2019-2022 cumulative improvement. The pattern by age changed in 2022 where mortality improvement was hump shaped with lower values at the endpoints of the age range from 25-34 at -2.3% to 85+ at -1.5% with a peak of 6.4% for ages 45-54.

There was also a distinct pattern for that same age range of the change in improvement by age between 2021 and 2022. That change decreased monotonically by age where it was 12.9% for ages 25-34 (-15.2% in 2021 and -2.3% in 2022) and -4.1% for ages 85+ (-2.6% in 2021 and -1.5% in 2022) and resulted in a tighter range of improvement by age in 2022 than the previous two years and the cumulative 2019-2022 period.

Figure 8

2022 HYPERTENSION HISTORICAL MORTALITY RATES AND MORTALITY IMPROVEMENT BY SELECTED PERIODS



All Ages	Average Annual Improvement		Cumulative Improvement*	Average Annual Improvement *		
	1999-2009	2009-2019	2019-2022	2019-2020	2020-2021	2021-2022
All	-2.3%	-1.3%	-13.4%	-13.0%	-1.1%	0.8%
Male	-2.4%	-1.9%	-14.6%	-12.5%	-3.3%	1.3%
Female	-2.2%	-0.8%	-12.1%	-13.0%	0.4%	0.5%
Age Group (includes both sexes)						
< 1						
1 - 4						
5 - 14						
15 - 24					-4.1%	0.8%
25 - 34	-4.2%	0.7%	-41.0%	-19.7%	-15.2%	-2.3%
35 - 44	-4.2%	-1.3%	-36.0%	-14.9%	-14.6%	-3.3%
45 - 54	-3.6%	-1.6%	-26.7%	-24.8%	-8.4%	6.4%
55 - 64	-2.5%	-3.3%	-22.4%	-20.3%	-4.7%	2.9%
65 - 74	-0.7%	-2.5%	-16.8%	-13.9%	-4.4%	1.7%
75 - 84	-1.6%	-0.6%	-9.9%	-11.2%	-0.8%	1.9%
85+	-3.2%	-0.9%	-9.3%	-10.6%	2.6%	-1.5%

* Estimated rates for 2019-2022 are derived using CDC WONDER death counts and modified population counts. 2019-2022 cumulative and average annual mortality improvement is derived with these rates. See Section 7 for details.

5.12 ACCIDENTS EXCLUDING OPIOIDS

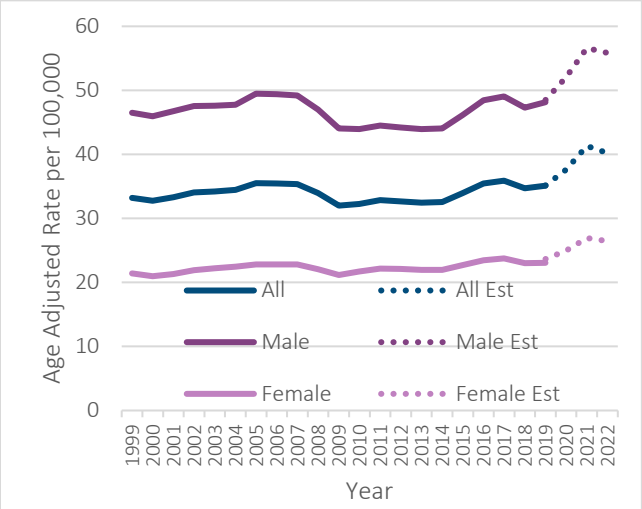
The cumulative mortality improvement rate over 2019-2022 for accidents excluding opioids was -14.4%. Within the three-year cumulative period, one-year improvement hit its low in 2020-2021 at -9.8% and saw a large reversal to 2.7% in the following year ended 2022. Motor vehicle accidents (MVA) and falls are the largest portion of this COD's deaths. During the 2019-2022 period, they had cumulative three-year mortality improvement rates of -16.8% and -12.8%, respectively. The 2022 one-year mortality improvement rate of MVAs at 3.0% in 2022 was the first year of positive improvement since the start of the pandemic. Males had lower three-year cumulative accidents excluding opioid mortality improvement of -15.2% in 2019-2022 than females at -11.8%, and within the three-year period also had lower one-year improvement in each year ending 2020-2022. Mortality improvement for both sexes reached a low in the second year of the pandemic and notably reversed to positive improvement in the year ended 2022. Mortality improvement for males and females was -8.8% and -7.9%, respectively, in 2021 and was 1.3% and 1.8%, respectively, in 2022.

For accidents excluding opioids, age group cumulative mortality improvement during 2019-2022 varied by age in a wave-like pattern. Every age group with available data[7] had negative cumulative mortality improvement over this three-year period. The combination of mortality rates and population by age group drives the degree of an age group's contribution to the age adjusted rate. Working ages 25-64 produced about 50% of the impact to the age adjusted rates for each year, and senior ages 65 and older contributed about 40%. Generally, these working ages had lower cumulative 2019-2022 improvement than other ages, and ages 35-44 had the lowest improvement of -23.0% of all age groups. Senior ages had mortality improvement for the same period that ranged from a low of -16.3% for ages 65-74 to -6.8% for ages 75-84. In the years ending 2020 and 2021, one-year mortality improvement rates by age group had a seesaw-type pattern. But in 2022 all ages saw increased one-year improvement rates. Positive improvement rates prevailed for ages from 1-4 to 45-54. Within these ages the lowest improvement at 1.6% occurred for ages 1-4 and highest was 6.4% at ages 15-24. Ages 55-64 and older had negative improvement which was lowest for ages 65-74 at -3.2% and highest for ages 55-64 at -0.2%. Generally, falls predominated relative to MVA as the highest type of accidental death for senior ages and it was the lower improvement rates for falls than MVA for seniors that produced negative one-year mortality improvement for all senior ages in the year ending 2022.

[7] Accidents excluding opioids are derived by subtracting accidents with opioids from accidents. Because accidents with opioids are suppressed by WONDER for some ages with low death counts, accidents excluding opioids cannot be calculated for those ages.

Figure 9

2022 ACCIDENTS EXLC OPIOIDS HISTORICAL MORTALITY RATES AND MORTALITY IMPROVEMENT BY SELECTED PERIODS



All Ages	Average Annual Improvement		Cumulative Improvement*	Average Annual Improvement *		
	1999-2009	2009-2019	2019-2022	2019-2020	2020-2021	2021-2022
All	0.4%	-0.9%	-14.4%	-7.1%	-9.8%	2.7%
Male	0.5%	-0.9%	-15.2%	-7.3%	-8.8%	1.3%
Female	0.1%	-0.9%	-11.8%	-5.5%	-7.9%	1.8%
Age Group (includes both sexes)						
< 1						
1 - 4			-14.9%	-1.8%	-14.7%	1.6%
5 - 14			-8.4%	-3.8%	-11.5%	6.2%
15 - 24	3.4%	2.2%	-10.4%	-13.6%	-3.8%	6.4%
25 - 34	0.5%	-0.3%	-20.2%	-17.1%	-8.3%	5.2%
35 - 44	0.6%	-1.1%	-23.0%	-13.4%	-12.9%	3.9%
45 - 54	-1.9%	-0.4%	-16.0%	-9.8%	-9.2%	3.3%
55 - 64	-0.5%	-3.0%	-19.7%	-8.2%	-10.4%	-0.2%
65 - 74	0.8%	-1.9%	-16.3%	-1.9%	-10.6%	-3.2%
75 - 84	-0.3%	-1.1%	-6.8%	1.8%	-7.5%	-1.2%
85+			-8.2%	-2.0%	-4.7%	-1.4%

* Estimated rates for 2019-2022 are derived using CDC WONDER death counts and modified population counts. 2019-2022 cumulative and average annual mortality improvement is derived with these rates. See Section 7 for details.

5.13 OPIOIDS

The cumulative mortality improvement rate over 2019-2022 for opioids, which intersects a key component of accident deaths, was -63.4%. While this was a radical deterioration of mortality improvement that moderated in 2018-2019 from earlier high deterioration during 2014-2017, the most recent one-year improvement in 2021-2022 showed substantial continued moderation that started in the prior year. The extreme one-year 2020 mortality improvement of -38.5% was the lowest one-year mortality improvement during the span of this study but was followed by -16.5% and -1.2% one-year mortality improvement in 2021 and 2022, respectively.

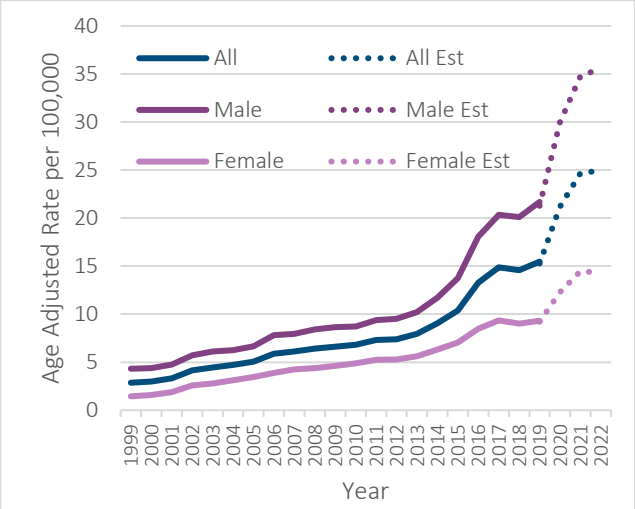
Males had lower cumulative mortality improvement of -67.3% in 2019-2022 than females at -55.2%. Females and males had strongly upward trending one-year mortality improvement for the years ending 2020-2022 which ended 2022 with female and male one-year improvement of 1.2% and -2.4%, respectively. The positive 2022 female improvement is notable because it is the first decrease of mortality since it last occurred in 2018, which is the only other year in this study that had a positive improvement rate for either sex. Although there was a recent moderation of increased mortality rates in 2022, they are substantially above their pre-pandemic level and the relatively flat short-term trend that occurred just before the pandemic.

Age group cumulative mortality improvement during 2019-2022 varied in an irregular pattern that all reflected negative improvement rates. The youngest ages had the lowest mortality improvement rates substantially below -100% that stepped up to a moderate downtrend from ages 15-24 to 65-74, where mortality improvement rates were in a range from -51.2% to -85.5% and then increased again to -33.0% and -1.0% for age groups 75-84 and ages 85+, respectively. The combinations of mortality rates and associated population weightings resulted in almost 97% of the impact to the age adjusted rate coming from ages from 15-24 to 55-64. Like age adjusted rates, that range of ages saw increasing one-year mortality improvement rates across the three one-year periods ending 2022. Those ages had a decreasing pattern of improvement by age in 2022. Ages 15-24 and 25-34 broke through with positive improvement of 10.8% and 3.8%, respectively, and ages 35-44, 45-54, and 55-64 had negative improvement rates of -3.1%, -3.8%, and – 6.4%, respectively.

The online Tableau “Opioid Deaths by Opioid Type” dashboard (included as companion information to this study) provides perspective on the source of overdose types across the span of this report. In recent years, tramadol and fentanyl, classified as Other Synthetic Opioids, experienced a -97.5% cumulative mortality improvement rate over 2019-2022. The cumulative mortality improvement rate was comprised of negative mortality improvement that lessened substantially in degree, going from one-year mortality improvement of -55.1% in 2020 to -22.7% in 2021 and -3.8% in 2022. Heroin, methadone, and natural and semi-synthetic opioids had 2019-2022 cumulative mortality improvement of 60.4%, -17.9%, and 2.5%, respectively. But all three types of those opioids, like tramadol and fentanyl, saw a continuation of increased rates of improvement that started in 2021 extended into 2022. The 2020-2022 one-year mortality improvement rates for heroin were 6.8%, 32.3%, and 37.2%, respectively; methadone was -28.7%, -1.0%, and 9.3%, respectively; and natural and semi-synthetic opioids were -13.6%, 0.7%, and 13.6%, respectively. Because opioid death rates for heroin, methadone, and natural and semi-synthetic opioids are much lower than tramadol and fentanyl overdoses, they had less impact on the total opioid death statistics.

Figure 10

2022 OPIOIDS HISTORICAL MORTALITY RATES AND MORTALITY IMPROVEMENT



All Ages	Average Annual Improvement		Cumulative Improvement*	Average Annual Improvement *		
	1999-2009	2009-2019	2019-2022	2019-2020	2020-2021	2021-2022
All	-8.7%	-8.9%	-63.4%	-38.5%	-16.5%	-1.2%
Male	-7.2%	-9.6%	-67.3%	-40.8%	-16.1%	-2.4%
Female	-12.3%	-7.2%	-55.2%	-33.2%	-17.9%	1.2%
Age Group (includes both sexes)				-		
< 1						
1 - 4		-4.0%	-327.2%	-51.7%	-83.0%	-53.9%
5 - 14		-2.6%	-255.7%	-97.9%	-18.8%	-51.3%
15 - 24	-12.3%	-5.5%	-51.2%	-61.1%	-5.2%	10.8%
25 - 34	-10.0%	-10.5%	-47.6%	-37.6%	-11.6%	3.8%
35 - 44	-4.7%	-10.2%	-71.3%	-40.7%	-18.0%	-3.1%
45 - 54	-9.5%	-6.2%	-65.3%	-34.1%	-18.8%	-3.8%
55 - 64	-16.8%	-10.4%	-75.5%	-30.9%	-26.0%	-6.4%
65 - 74	-13.8%	-12.7%	-85.5%	-24.7%	-29.7%	-14.7%
75 - 84	-7.4%	-6.3%	-33.0%	6.8%	-19.9%	-19.1%
85+		-3.1%	-1.0%	-5.1%	-8.2%	11.2%

* Estimated rates for 2019-2022 are derived using CDC WONDER death counts and modified population counts. 2019-2022 cumulative and average annual mortality improvement is derived with these rates. See Section 7 for details.

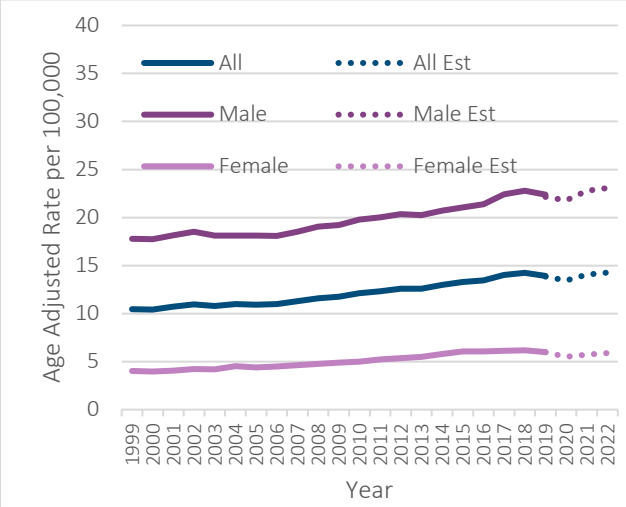
5.14 SUICIDE

The cumulative mortality improvement rate over 2019-2022 for suicide was -2.9%. Although negative, that mortality improvement rate, uncharacteristic of most CODs, had embedded one-year positive improvement of 3.0% in the first year of the pandemic ending 2020. The following two years ending 2021 and 2022 saw one-year improvement of -4.6% and -1.5%, respectively. Males had notably lower three-year cumulative mortality improvement of -4.1% in 2019-2022 than females at 1.4%. Female and male one-year improvement swung from positive in 2020 to negative in years ending 2021 and 2022 but with lower absolute values in 2022 where female and male improvement was -2.9% and -1.3%, respectively. Mortality improvement (all ages and both sexes combined) in 2020 combined with increases in 2021 and 2022 produced a moderate upward trend of mortality that was generally in line or slightly below the long-term increasing trend seen in 2009-2019.

Age group cumulative mortality improvement during 2019-2022 varied by age with no discernable pattern. Age groups spanning ages 15-44 and 65 and above had negative 2019-2022 cumulative mortality improvement. It ranged from -11.9% for ages 85+ to -0.6% for age group 15-24. Age groups spanning ages 45-64 and 5-14 had positive mortality improvement during that time, ranging from 0.2% for age group 45-54 to 6.1% for age group 5-14. In the most recent year mortality rates declined with improvement of 8.2% and 2.3% for ages 15-24 and 25-34, respectively, in 2022. Those ages comprised about 32% of the impact on the age adjusted rate. Conversely, ages older than 34 had negative improvement and comprised about 68% of the corresponding impact with most of that coming from the working ages in that range. The net effect produced the negative one-year improvement rates of -1.5% for all ages combined in 2022.

Figure 11

2022 SUICIDE HISTORICAL MORTALITY RATES AND MORTALITY IMPROVEMENT



All Ages	Average Annual Improvement		Cumulative Improvement*	Average Annual Improvement *		
	1999-2009	2009-2019	2019-2022	2019-2020	2020-2021	2021-2022
All	-1.2%	-1.7%	-2.9%	3.0%	-4.6%	-1.5%
Male	-0.8%	-1.5%	-4.1%	1.7%	-4.6%	-1.3%
Female	-2.0%	-2.1%	1.4%	7.8%	-3.9%	-2.9%
Age Group (includes both sexes)						
< 1						
1 - 4						
5 - 14	-0.8%	-7.5%	6.1%	-10.7%	-1.6%	16.6%
15 - 24	0.1%	-3.4%	-0.6%	-2.1%	-7.4%	8.2%
25 - 34	-0.3%	-3.0%	-8.3%	-5.3%	-5.2%	2.3%
35 - 44	-1.2%	-1.2%	-5.3%	3.8%	-6.2%	-3.0%
45 - 54	-3.3%	-0.2%	0.2%	8.3%	-3.1%	-5.6%
55 - 64	-3.0%	-1.7%	2.9%	13.1%	-2.1%	-9.4%
65 - 74	-0.2%	-1.2%	-2.5%	6.5%	-5.6%	-3.8%
75 - 84	1.3%	-1.6%	-5.3%	1.0%	-2.0%	-4.2%
85+	1.6%	-2.1%	-11.9%	-4.0%	3.4%	-11.3%

* Estimated rates for 2019-2022 are derived using CDC WONDER death counts and modified population counts. 2019-2022 cumulative and average annual mortality improvement is derived with these rates. See Section 7 for details.

Section 6: Additional Supporting Material

The remaining content of the report is online in two interactive dashboards, which can be found on the same webpage where the pdf of this report is located. In the dashboards, the individually listed CODs are also shown on a combined basis by physiological and external causes, plus an option to see All CODs without COVID. Given the continued interest in opioid-related deaths, opioids are shown as a COD, as are the accidents excluding opioids analysis, and they are shown in an exhibit of deaths by opioid type for all ages and sexes. The COD variation of interest can be viewed in the first two dashboards by using a drop-down box at the top right of the data board. The "U.S. Population Mortality by Sex" dashboard includes a graph of age-adjusted death rates from 1999-2022 by sex and both sexes combined, and a related table with corresponding average annual mortality improvement rates. The table shows experience by sex for all ages combined and by combined sex for age groups. The 2022 average annual mortality improvement rates are shown over the 1999 to 2009 and the 2009 to 2019 time periods, along with cumulative improvement from 2019 to 2022 and one-year improvement rates ending in 2020, 2021, and 2022. The second dashboard, "Opioid Deaths by Opioid Type" shows the exhibit of opioid deaths by opioid type. All data supporting this report and the dashboards are included in an appendix in the form of an Excel file that can be found on the same webpage where this report and these dashboards are located.

Section 7: WONDER Mortality Rates and 2019-2022 Alternative Estimates

The main source of the mortality rates found in this report was the Centers for Disease Control and Prevention's (CDC) Wide-ranging Online Data for Epidemiologic Research (WONDER) database, released in April 2024[8] and modifications made to that data to produce alternative estimates of mortality rates for 2019-2022.

The mortality rates from WONDER are based on annual death data and, generally, mid-year populations. For any mortality rate calculation, deaths for age x are equal to calendar year deaths between ages x and x+1 and the populations are estimates from the U.S. Census Bureau. See the CDC WONDER 'Dataset Documentation' for more information.[9]

This report has historically, since its inception for the 2016 experience year, used WONDER data as given without any modifications. But because of concerns about population estimates during the pandemic, this report has derived estimated mortality rates for 2019-2022 that are based on the deaths reported in WONDER but use alternative population estimates (as of this writing) than are carried in WONDER to derive mortality rates for those years. Specifically, complications from the pandemic and other data gathering challenges during the normal 2020 full U.S. census delayed the release of population estimates post 2020 that could include the 2020 census count as a foundation for those estimates. Estimates that have been released and used in WONDER for some of the years in question are not (as of this writing) using a population estimate that includes the 2020 census as a foundation for projection of future year's populations (postcensal populations estimates).[10]

Population estimates by the U.S. Census Bureau are refined over time by estimating change from the most recent full census population count. The estimated increments from births, deaths, and net migration from the base year to subsequent years can change as they are refined over time. The sets of estimated calendar years of population counts for a point in time are referred to as the vintage of the data captured for those years. This report has used the U.S. Census Bureau vintage 2023 estimate of 2020-2022 population to derive mortality rates for those years.[11] This vintage was chosen for mortality rate estimates in this report because it is the most current and includes the 2020 census data in developing the estimated population counts.[12] Because no comparable estimate was available for 2019 (its estimate is based on estimated change from 2010 census data), the 2019 population was estimated by adding deaths to the 2020 population.[13]

Age group mortality rates in this report are derived using calendar-year deaths and population (substituted with alternative U.S. Census estimates as noted above for 2019-2022) from WONDER with rates per 100,000 rounded to six decimal places. All subsequent calculations for mortality improvement and age-adjusted mortality rates use these rounded rates. The report retains the historical 1999-2019 mortality rates to show long term mortality rate trends and associated long term average annual mortality improvement. The estimated 2019-2022 mortality rates (based on population modifications) are used to show experience since the pandemic.

---

[8] Centers for Disease Control and Prevention, National Center for Health Statistics. CDC WONDER Online Database, released in 2024. Underlying Cause of Death data are from 1999-2020 Underlying Cause of Death by Bridged-Race Categories database and 2018-2022 Underlying Cause of Death by Single-Race Categories database, https://wonder.cdc.gov/Deaths-by-Underlying-Cause.html. Multiple Cause of Death data are from 1999-2020 Current Final Multiple Cause of Death by Bridged-Race Categories database and 2018-2022 Current Final Multiple Cause of Death by Single Race Categories database, https://wonder.cdc.gov/mcd.html. Data was compiled from bridged-race categories for 1999-2020 and single-race categories for 2021-2022. Data queries were cross checked by comparing 2018-2020 of the bridged-race to 2018-2020 of the single-race data. Data was accessed on various dates in April 2024.

[9] Source: https://wonder.cdc.gov/wonder/help/ucd.html#

[10] https://wonder.cdc.gov/wonder/help/ucd-expanded.html#Population%202021

[11] National Population by Characteristics: 2020-2024

[12] methods-statement-v2023.pdf

[13] Age_x-1,2019 Pop = Age_x,2020 Pop + .5 * (Age_x-1,2019 Deaths + Age_x,2020 Deaths)

The difference of the assumed 2019 population in WONDER (vintage 2019) relative to the estimated 2019 population (deaths added back to 2020 population in vintage 2023) produces different 2019 mortality rates. The degree of the mortality rate difference varies across age groups. The greatest difference in population assumed occurs for ages 75-84 and ages 85+ where the 2019 estimated population was 8.7% and 3.7% lower for those ages, respectively, than the WONDER population. The difference of age adjusted mortality rates resulting from the populations assumed depends on the age specific mortality nature of a COD and the associated population differences at those ages. The all causes of death and both sexes combined age adjusted mortality rates were 739.5 and 715.2 deaths per 100,000 or 3.4% higher for the estimated compared to the WONDER basis. Heart disease had a 4.2% higher age adjusted mortality rate for the estimated basis than WONDER while liver was 0.2% lower. The impact of the different population assumptions on mortality improvement is discussed next.

Tables 9 and 10 provide information on the differences of age adjusted mortality improvement rates and the associated population data, respectively, of the estimated and WONDER bases used to construct mortality rates. On an age adjusted basis there was little difference in the 2019-2020 mortality improvement but notable differences for the years ending 2021 and 2022. The 2021 and 2022 differences of the age adjusted mortality improvement rates are explained by the underlying population differences used to produce mortality rates for the estimated and WONDER bases. Table 10 expresses the population differences (estimated minus WONDER) as a percentage of the WONDER population basis.

The mortality improvement differences are largest where the second order difference across years of the population differences is greatest. For example, at ages 85+ the estimated compared to WONDER population differences are -8.7% and -9.0% for 2019 and 2020. Because the deaths are the same in both associated mortality rate estimates, the one-year improvement on the estimated and WONDER bases are similar. Conversely, the ages 85+ population differences of -9.0% for 2020 and 1.1% for 2021 result in higher one-year mortality improvement on the estimated compared to WONDER bases in the year ending 2021. When this effect is combined with mortality rates by age, it indicates the expected differences of age adjusted mortality improvement on the estimated basis relative to WONDER. Because mortality rates are highest for the oldest ages the associated population differences for those ages have a magnified effect on age adjusted mortality rate improvement on the estimated compared to the WONDER basis. The higher mortality rates of ages 75+, their concentration in physiological causes and population differences explains the age adjusted mortality differences between the estimated and WONDER bases. The estimated age adjusted all causes of death one-year mortality improvement was 3.8% and -2.1% higher than WONDER in 2021 and 2022, respectively. A similar effect occurred for physiological CODs where the corresponding differences for the same years were 4.2% and -2.2%. The same differences for external CODs, 0.4% and -0.7%, respectively, were smaller because the population differences for ages where the greatest proportion of external deaths occur were smaller.

The overall impact of the population adjustments used to derive mortality rates for this report means that one-year mortality improvement is about the same for 2020 and higher for 2021 than reported in last year's 2021 report update. It also implies that considering the 2022 estimated mortality rates that the stated 2019-2022 cumulative mortality improvement is 1.6% higher in this report than it would have been without any adjustments. The amount of any difference of age adjusted mortality improvement between the estimates used for the report and WONDER bases by cause of death is dependent on the concentration of deaths by age and the associated population differences at those ages.

Table 9

ESTIMATED LESS WONDER U.S. POPULATION AGE ADJUSTED MORTALITY IMPROVEMENT

	Cumulative Improvement	Average Annual Improvement		
	2019 -2022	2019 -2020	2020 -2021	2021 -2022
All	1.6%	-0.1%	3.8%	-2.1%
External	-0.3%	0.0%	0.4%	-0.7%
Physiological	1.8%	-0.1%	4.2%	-2.2%

Table 10

ESTIMTATED LESS WONDER U.S. POPULATION AS PERCENTAGE OF WONDER BY AGE GROUP

Age Group	2019	2020	2021	2022
< 1 year	-0.2%	-0.9%	0.2%	-0.3%
1-4 years	0.7%	0.1%	0.1%	0.9%
15-24 years	1.0%	1.1%	0.1%	-1.9%
25-34 years	-0.2%	-0.9%	0.1%	0.1%
35-44 years	1.9%	1.8%	0.0%	0.4%
45-54 years	1.8%	1.8%	0.0%	0.2%
5-14 years	3.1%	2.6%	0.1%	1.3%
55-64 years	1.4%	1.5%	0.0%	0.5%
65-74 years	-0.2%	0.1%	-0.1%	0.6%
75-84 years	-3.7%	-3.8%	0.0%	-0.6%
85+ years	-8.7%	-9.0%	1.1%	-6.6%
All Ages	0.8%	0.6%	0.0%	0.0%

Section 8: Methodology

Mortality improvement rates in this report, as described in Section 7, are expressed in geometric average annual and cumulative rates of improvement. They are derived as follows for age x over an n year period ending in calendar year CY.

Average annual rate of improvement:

$$1 - \left(\frac{q_x^{CY}}{q_x^{CY-n}} \right)^{\left(\frac{1}{n}\right)}$$

Cumulative rate of improvement:

$$1 - \left(\frac{q_x^{CY}}{q_x^{CY-n}} \right)$$

All mortality rates shown in this report, other than those shown for 10-year age groups, are age-adjusted rates based on the CDC's 2000 U.S. Standard Population. This is a change from prior reports (through the experience year 2020) that used the non-standard population in 2010, which was chosen for those reports because 2010 was more central to the mid-point of the years evaluated. That option was eliminated in WONDER. The 2000 standard population was chosen based on year 2000 being within the range of years evaluated in this report and of the two choices, 2000 and 2020, the one which was based on a more reliable final census estimate for that year. To achieve consistent comparisons across sex, all age-adjusted rates were determined using the 2000 combined female and male age group distribution. Age-adjusted mortality rates and improvement in this report are based on age only with no demographic adjustments for mixes of sex or race.

Age-adjusted rates in this report are calculated as follows using 2000 as the base year and rounded to six decimal places.

$$\sum_{n=1}^{11} Pct_{Age_n} * q_{Age_n}$$

Where:

Age_n = Age group *n* (11 age groups)[14]

Pct_{Age_n} = % of age group *n* 2000 Population

q_{Age_n} = Calendar year crude q_x for age group *n*

[14] Age adjusted mortality rates can be calculated by individual ages within WONDER. The current, as of this writing, 2023 one-year age adjusted mortality rate for all causes and both sexes combined was 0.2% higher on an individual basis than if based on 11 age groups. While the mortality rates on each basis are different the impact on associated mortality improvement rates would be minimized as mortality rates could be expected to be affected similarly across years assuming the same base year for an individual age or age grouped basis.

Attributions of 2019-2022 cumulative mortality improvement by ages and CODs shown in Section 4 are determined as follows:

Age Group Attribution

Age group n attribution to all ages improvement is:

$$\frac{Pct_{Age_1} * q_{Age_1}}{\sum_{n=1}^{11} Pct_{Age_n} * q_{Age_n}} * Improvement_{Age_1}$$

Where:

Age_n = Age group *n* (11 age groups)

Pct_{Age_n} = % of age group *n* 2000 Population

q_{Age_n} = 2019 Crude q_x for age group *n*

$Improvement_{Age_n}$ = Age group *n* 2022 cumulative mortality improvement rate from 2019

q_{Age_n} and $Improvement_{Age_n}$ are based on crude rates per 100,000 lives rounded to one decimal place, which is consistent with age-adjustment calculation methodology.[15]

COD Attribution

COD is simpler because COD mortality improvement is already expressed on an age-adjusted basis. Unrounded values are used.

COD_n, attribution to all causes mortality improvement is:

$$\frac{q^{COD_n}}{q^{COD_{All}}} * Improvement_{COD_n}$$

Where:

q^{COD_n} = 2019 COD_n age-adjusted mortality rate

$q^{COD_{All}}$ = 2019 age-adjusted mortality rate for all causes of mortality

$Improvement_{COD_n}$ = COD_n 2022 cumulative mortality improvement rate from 2019

To meet the CDC's privacy data use requirements, calculated annual improvement values are not shown for age groups where the number of deaths for that age group was less than 10 in any one year.

[15] Source: https://wonder.cdc.gov/wonder/help/ucd.html#

The NCHS's rankable causes of death are a subset of its "113 Selected Causes of Death." The selected 14 causes of death covered in the report are, with four exceptions, the top five rankable causes of death in 2022 for each of the 10-year age and sex groups available in WONDER. Because of limited interest, two of the top five rankable CODs that were present up to age 14 were excluded,[16] while kidney and hypertension, which were not in the top five rankable causes, were included due to interest in those CODs. Below is a table of the 14 selected causes of death covered in this report and their International Classification of Diseases, Tenth Revision[17] (ICD-10) 113 Code and Cause List as they appear in WONDER.

Report Cause of Death	ICD-10 113 Code	ICD-10 113 Cause List (with ICD-10 codes)
Physiological:		
Alzheimer's/Dementia[18]	GR113-052	#Alzheimer's disease (G30)
Cancer:		
All Causes	GR113-019	#Malignant neoplasms (C00-C97)
Breast	GR113-029	Malignant neoplasm of breast (C50)
Colon	GR113-023	Malignant neoplasms of colon, rectum, and anus (C18-C21)
Lung	GR113-027	Malignant neoplasms of trachea, bronchus, and lung (C33-C34)
Prostate	GR113-033	Malignant neoplasm of prostate (C61)
COVID	GR113-137	COVID-19 (U07.1)
Diabetes	GR113-046	#Diabetes mellitus (E10-E14)
Flu & pneumonia	GR113-076	#Influenza and pneumonia (J09-J18)
Heart	GR113-054	#Diseases of heart (I00-I09, I11, I13, I20-I51)
Hypertension	GR113-069	#Essential hypertension and hypertensive renal disease (I10, I12, I15)
Kidney	GR113-097	#Nephritis, nephrotic syndrome, and nephrosis (N00-N07,N17-N19,N25-N27)
Liver	GR113-093	#Chronic liver disease and cirrhosis (K70, K73-K74)
Pulmonary	GR113-082	#Chronic lower respiratory diseases (J40-J47)
Stroke	GR113-070	#Cerebrovascular diseases (I60-I69)
External:		
Accidents	GR113-112	#Accidents (unintentional injuries) (V01-X59, Y85-Y86)
Assault	GR113-127	#Assault (homicide) (*U01-*U02, X85-Y09, Y87.1)
Suicide	GR113-124	#Intentional self-harm (suicide) (*U03, X60-X84, Y87.0)

For opioid deaths by opioid type, the method to identify drug overdose deaths involving opioids was taken from the Increases in Drug Overdose Deaths in the United States, 1999–2018.[19] These deaths were identified by the ICD-10 underlying cause-of-death codes X40–44 (unintentional), X60–64 (suicide), X85 (homicide), or Y10–Y14 (undetermined intent) in combination with any one of the following multiple cause-of-death codes: opium (T40.0); heroin (T40.1); natural/semisynthetic opioids (T40.2); methadone (T40.3); synthetic opioids other than methadone (T40.4); or other and unspecified narcotics (T40.6).

[16] GR113-108 - Certain conditions originating in the perinatal period (P00-P96), present at age less than one and GR113-109 - Congenital malformations, deformations, and chromosomal abnormalities (Q00-Q99), present up to age 14.
[17] World Health Organization https://icd.who.int/browse10/2016/en
[18] Dementia is not one of the NCHS's rankable causes of death but has been included with the review of Alzheimer's. The ICD-10 codes for Dementia are (F01, F03)
[19] Hedegaard H, Miniño AM, Warner M. Drug overdose deaths in the United States, 1999–2018. NCHS Data Brief, no 356. Hyattsville, MD: National Center for Health Statistics. 2020.

Appendices with the following data and information can be found in an accompanying Excel file.

A. Age-Adjusted Death Rates used to produce graphs, tables, and observations in this report.
B. Age Group Rates used to produce tables and observations in this report.
C. Links to sample CDC WONDER queries[20] used to pull values for the 'All' and 'Opioid' CODs analyses.

[20] The SOA is not responsible if these links do not continue to work and will not update them if they break.

Section 9: Reliance and Limitations

Data to calculate mortality rates in this report were drawn from the Centers for Disease Control and Prevention (CDC) Wide-ranging Online Data for Epidemiologic Research (WONDER) database and the U.S. Census Bureau vintage 2023 estimate of 2020-2022 population. There are limited instances where the mortality rates and associated mortality improvements are not shown. This is because death counts of less than 10 for sub-national data are suppressed by WONDER.

Data provided through WONDER is subject to restricted use for health statistical reporting and analysis. This research confines itself to those parameters. While the data may be useful for application in specific purposes, no assessment has been made concerning the applicability of this experience to other such purposes.

Opioid deaths overlap with the accident, assault, and suicide deaths analyzed in this report. The opioid deaths have a meaningful impact on the accident results and, therefore, have been removed from the accident deaths in a separate COD analysis shown as accident excluding opioids. The impact of opioid deaths in the assault and suicide analyses was deemed to be immaterial and, therefore, not included in this report.

This report does not attempt to comment on changes or improvements in the process to record cause of death codes over the report horizon and their potential impact on observations noted in this report. For example, possible limitations regarding the accuracy or completeness of the assignment of COD could affect the determination of the accidents excluding opioids COD in this report. Some of the deaths associated with the increases in 2016-2022 that were not identified as opioid-related to determine the accidents excluding opioid deaths could, in fact, be opioid-related. Insights regarding the mortality reporting process with a focus on COVID were provided by Robert Anderson, Chief of Mortality Statistics at NCHS, in a 2021 podcast.[21] The CDC provided guidance to certifiers on COVID mortality reporting in 2020[22] as an update to the general concepts published in 2003.[23]. Potential changes in recording processes should be considered if utilizing the information provided in this report.

[21] Death Certificate Data & COVID-19: Interview with Robert Anderson, Part One (cdc.gov)
[22] https://www.cdc.gov/nchs/data/nvss/vsrg/vsrg03-508.pdf
[23] https://www.cdc.gov/nchs/data/misc/hb_cod.pdf

Section 10: Acknowledgments

The researcher's deepest gratitude goes to the oversight group and others for their diligent work overseeing the report design, compiling the data for analysis, and reviewing and editing this report for accuracy and relevance.

Mary Pat Campbell, FSA, MAAA

Micah Canaday, ASA

Ed Hui, FSA, MAAA, CFA

Patrick Keough, FSA, MAAA

At the Society of Actuaries Research Institute

Pete Miller, ASA, MAAA, Experience Studies Actuary

Barbara Scott, Senior Research Administrator

About The Society of Actuaries Research Institute

Serving as the research arm of the Society of Actuaries (SOA), the SOA Research Institute provides objective, data-driven research bringing together tried and true practices and future-focused approaches to address societal challenges and your business needs. The Institute provides trusted knowledge, extensive experience and new technologies to help effectively identify, predict and manage risks.

Representing the thousands of actuaries who help conduct critical research, the SOA Research Institute provides clarity and solutions on risks and societal challenges. The Institute connects actuaries, academics, employers, the insurance industry, regulators, research partners, foundations and research institutions, sponsors and non-governmental organizations, building an effective network which provides support, knowledge and expertise regarding the management of risk to benefit the industry and the public.

Managed by experienced actuaries and research experts from a broad range of industries, the SOA Research Institute creates, funds, develops and distributes research to elevate actuaries as leaders in measuring and managing risk. These efforts include studies, essay collections, webcasts, research papers, survey reports, and original research on topics impacting society.

Harnessing its peer-reviewed research, leading-edge technologies, new data tools and innovative practices, the Institute seeks to understand the underlying causes of risk and the possible outcomes. The Institute develops objective research spanning a variety of topics with its strategic research programs: aging and retirement; actuarial innovation and technology; mortality and longevity; diversity, equity and inclusion; health care cost trends; and catastrophe and climate risk. The Institute has a large volume of topical research available, including an expanding collection of international and market-specific research, experience studies, models and timely research.

Society of Actuaries Research Institute
8770 W Bryn Mawr Ave, Suite 1000
Chicago, IL 60631
www.SOA.org